



**BUREAU  
VERITAS**

# TEST REPORT

## DIN VDE V 0124-100

Test requirements for generation units to be connected and operated parallel with the low voltage distribution networks

Report reference number .....: PVDE200320N031-2-R1

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Total number of pages .....: 149

Testing laboratory name.....: Bureau Veritas Shenzhen Co., Ltd. Dongguan Branch

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Accreditation.....:



Applicant's name.....: Shenzhen SOFAR SOLAR Co., Ltd.

Address .....: 401, Building 4, AnTongDa Industrial Park, District 68, XingDong Community, XinAn Street, BaoAn District, Shenzhen, China

### Test specification

Standard.....: VDE AR-N 4105:2018-11

DIN VDE V 0124-100:2020-06

Test Report Form No.....: DIN VDE V 0124-100 VER.2

TRF Originator.....: Bureau Veritas Shenzhen Co., Ltd. Dongguan Branch

Master TRF .....: Dated 2020-08-06

Test item description .....: Solar Grid-tied Inverter



Trademark .....:



Model / Type.....: SOFAR 3300TL-G3, SOFAR 3000TL-G3, SOFAR 2700TL-G3, SOFAR 2200TL-G3, SOFAR 1600TL-G3, SOFAR 1100TL-G3

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| <b>Ratings .....</b>                         | <b>SOFAR 1100TL-G3</b> | <b>SOFAR 1600TL-G3</b> | <b>SOFAR 2200TL-G3</b> |
|--|------------------------|------------------------|------------------------|
| Input DC voltage [V] .....                   | Max. 500V              |                        |                        |
| MPP DC voltage range [V] .....               | 50-500V                |                        |                        |
| Input DC current [A].....                    | 12,0A                  |                        |                        |
| Output AC voltage [V].....                   | L/N/PE, 230Vac         |                        |                        |
| Output AC current [A] .....                  | Max. 5,3A              | Max. 7,7A              | Max. 10,6A             |
| Initial short-current AC current $I_k$ [A].: | 16                     | 16                     | 16                     |
| Output power [VA] .....                      | 1100                   | 1600                   | 2200                   |
| <b>Ratings .....</b>                         | <b>SOFAR 2700TL-G3</b> | <b>SOFAR 3000TL-G3</b> | <b>SOFAR 3300TL-G3</b> |
| Input DC voltage [V] .....                   | Max. 550V              |                        |                        |
| MPP DC voltage range [V] .....               | 50-550V                |                        |                        |
| Input DC current [A].....                    | 12,0A                  |                        |                        |
| Output AC voltage [V].....                   | L/N/PE, 230Vac         |                        |                        |
| Output AC current [A] .....                  | Max. 13,0A             | Max. 14,5A             | Max. 16,0A             |
| Initial short-current AC current $I_k$ [A].: | 16                     | 16                     | 16                     |
| Output power [VA] .....                      | 2700                   | 3000                   | 3300                   |

|   |  |  |  |
|---|--|--|--|
| <b>Testing Location</b> .....                       | <b>Bureau Veritas Shenzhen Co., Ltd. Dongguan Branch</b>   |  |  |
| Address .....                                       | No. 96, Guantai Road (Houjie Section), Houjie Town, Dongguan City, Guangdong Province, 523942, People's Republic of China  |  |  |
| Tested by<br>(name, function and signature) .....   | Jack Shi   |  |  |
| Approved by<br>(name, function and signature) ..... | James Huang  |  |  |
| <b>Manufacturer's name</b> .....                    | <b>Shenzhen SOFAR SOLAR Co., Ltd.</b>  |  |  |
| Factory address.....                                | 401, Building 4, AnTongDa Industrial Park, District 68, XingDong Community, XinAn Street, BaoAn District, Shenzhen, China. |  |  |
| <b>Factory name</b> .....                           | <b>Dongguan SOFAR SOLAR Co.,Ltd.</b>   |  |  |
| Factory address.....                                | 1F - 6F, Building E, No. 1 JinQi Road, Bihu Industrial Park, Wulian Village, Fenggang Town, Dongguan City                  |  |  |

| <b>Document History</b>    |                    |  |          |
|----------------------------|--------------------|--|----------|
| Date                       | Internal reference | Modification / Change / Status                                 | Revision |
| 2020-08-30                 | Jack Shi           | Initial report was written                                     | 0        |
| 2020-10-12                 | Jack Shi           | Correct the Initial short-current AC current $I_{k''}$ to 16A. | R1       |
| Supplementary information: |                    |  |          |

|  |  |
|--|--|
| <b>Test items particulars</b>                        |  |
| Equipment mobility .....                             | Permanent connection   |
| Operating condition .....                            | Continuous   |
| Class of equipment.....                              | Class I  |
| Protection against ingress of water ..               | IP65 according to EN 60529   |
| Mass of equipment [kg] .....                         | Approx. 5,5kg (SOFAR 1100TL-G3, SOFAR 1600TL-G3,<br>SOFAR 2200TL-G3)<br><br>Approx. 6,3kg (SOFAR 2700TL-G3, SOFAR 3000TL-G3,<br>SOFAR 3300TL-G3) |
| <b>Test case verdicts</b>                            |  |
| Test case does not apply<br>to the test object ..... | N/A  |
| Test item does meet<br>the requirement .....         | P(ass)   |
| Test item does not meet<br>the requirement .....     | F(ail)   |
| <b>Testing</b>                                       |  |
| Date of receipt of test item .....                   | 2020-03-20   |
| Date(s) of performance of test .....                 | 2020-03-20 to 2020-08-28   |

### General remarks:

The test result presented in this report relate only to the object(s) tested. The report shall state compliance of the tested objects with the requirements of VDE-AR-N 4105 / DIN VDE V 0124-100. This report must not be reproduced in part or in full without the written approval of the issuing testing laboratory.

"(see Annex #)" refers to additional information appended to the report.

"(see appended table)" refers to a table appended to the report.

Throughout this report a comma is used as the decimal separator.

- "P<sub>rE</sub>" for the rated active power:

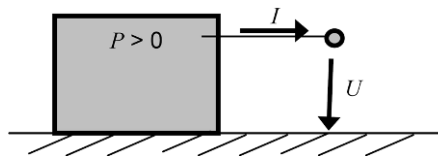
$$P_{rE} = U_n \times I_r \times \cos \varphi_n \text{ (single-Phase); } P_{rE} = \sqrt{3} U_n \times I_r \times \cos \varphi_n \text{ (three-Phase)}$$

- "P<sub>ref</sub>" for the momentary power
- " $\Delta P_{E60}$ " in [%] =  $(P_{\text{Setpoint}} - P_{E60}) / P_{rE}$
- " $\Delta Q_{E60}$ " in [%] =  $(Q_{\text{expected}} - Q_{E60}) / P_{E\text{max}}$
- "(c)" for over-excited
- "(i)" for under-excited

### Active and reactive power:

The regarded system of the voltage and current vectors is the load view (Figure 2):

- If the inverter feeds to the grid the active power is measured with negative sign. For the sake of reading the document the measured active infeed power has a positive sign.



- If the inverter consumes inductive reactive power the reactive power is marked "inductive" or has a positive sign.
- If the inverter consumes capacitive reactive power the reactive power is marked "capacitive" or has a negative sign.

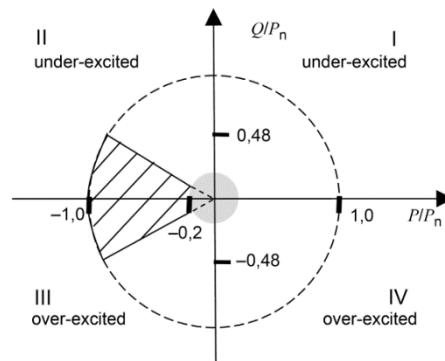




Figure 2

**This Test Report consists of the following documents:**


|                                       |     |
|---------------------------------------|-----|
| Test Results.....                     | 14  |
| Annex No. 1 Pictures of the unit..... | 141 |
| Annex No. 2 Test Equipment list.....  | 147 |
| End of Test Report.....               | 149 |



Copy of marking plate



| SOFAR SOLAR Solar Grid-tied Inverter   |                     |
|--|---------------------|
| Model No.  | SOFAR 1100TL-G3     |
| Max.DC Input Voltage   | 500V                |
| Operating MPPT Voltage Range   | 50~500V             |
| Max. Input Current   | 12A                 |
| Max. PV Isc  | 15A                 |
| Nominal Grid Voltage   | L/N/PE, 230Vac      |
| Max. Output Current  | 5.3A                |
| Nominal Grid Frequency   | 50/60Hz             |
| Max. Output Power  | 1100VA              |
| Power Factor   | 1(adjustable+/-0.8) |
| Ingress protection   | IP65                |
| Operating Temperature Range  | -30~+60°C           |
| Topology   | Non-isolated        |
| Protective Class   | Class I             |
| Manufacturer:Shenzhen SOFARSOLAR Co., Ltd.<br>Address: 401, Building 4, AnTongDa Industrial Park, District 68, XingDong Community, XinAn Street, BaoAn District, Shenzhen, China |                     |
| VDE0126-1-1, VDE-AR-N4105, IEC61727, IEC62116, UTE C15-712-1, AS4777   |                     |
|    |                     |

| SOFAR SOLAR Solar Grid-tied Inverter   |                     |
|--|---------------------|
| Model No.  | SOFAR 1600TL-G3     |
| Max.DC Input Voltage   | 500V                |
| Operating MPPT Voltage Range   | 50~500V             |
| Max. Input Current   | 12A                 |
| Max. PV Isc  | 15A                 |
| Nominal Grid Voltage   | L/N/PE, 230Vac      |
| Max. Output Current  | 7.7A                |
| Nominal Grid Frequency   | 50/60Hz             |
| Max. Output Power  | 1600VA              |
| Power Factor   | 1(adjustable+/-0.8) |
| Ingress protection   | IP65                |
| Operating Temperature Range  | -30~+60°C           |
| Topology   | Non-isolated        |
| Protective Class   | Class I             |
| Manufacturer:Shenzhen SOFARSOLAR Co., Ltd.<br>Address: 401, Building 4, AnTongDa Industrial Park, District 68, XingDong Community, XinAn Street, BaoAn District, Shenzhen, China |                     |
| VDE0126-1-1, VDE-AR-N4105, IEC61727, IEC62116, UTE C15-712-1, AS4777   |                     |
|   |                     |

| SOFAR SOLAR Solar Grid-tied Inverter   |                     |
|--|---------------------|
| Model No.  | SOFAR 2200TL-G3     |
| Max.DC Input Voltage   | 500V                |
| Operating MPPT Voltage Range   | 50~500V             |
| Max. Input Current   | 12A                 |
| Max. PV Isc  | 15A                 |
| Nominal Grid Voltage   | L/N/PE, 230Vac      |
| Max. Output Current  | 10.6A               |
| Nominal Grid Frequency   | 50/60Hz             |
| Max. Output Power  | 2200VA              |
| Power Factor   | 1(adjustable+/-0.8) |
| Ingress protection   | IP65                |
| Operating Temperature Range  | -30~+60°C           |
| Topology   | Non-isolated        |
| Protective Class   | Class I             |
| Manufacturer:Shenzhen SOFARSOLAR Co., Ltd.<br>Address: 401, Building 4, AnTongDa Industrial Park, District 68, XingDong Community, XinAn Street, BaoAn District, Shenzhen, China |                     |
| VDE0126-1-1, VDE-AR-N4105, IEC61727, IEC62116, UTE C15-712-1, AS4777   |                     |
|   |                     |

| SOFAR SOLAR Solar Grid-tied Inverter   |                     |
|--|---------------------|
| Model No.  | SOFAR 2700TL-G3     |
| Max.DC Input Voltage   | 550V                |
| Operating MPPT Voltage Range   | 50~550V             |
| Max. Input Current   | 12A                 |
| Max. PV Isc  | 15A                 |
| Nominal Grid Voltage   | L/N/PE, 230Vac      |
| Max. Output Current  | 13A                 |
| Nominal Grid Frequency   | 50/60Hz             |
| Max. Output Power  | 2700VA              |
| Power Factor   | 1(adjustable+/-0.8) |
| Ingress protection   | IP65                |
| Operating Temperature Range  | -30~+60°C           |
| Topology   | Non-isolated        |
| Protective Class   | Class I             |
| Manufacturer:Shenzhen SOFARSOLAR Co., Ltd.<br>Address: 401, Building 4, AnTongDa Industrial Park, District 68, XingDong Community, XinAn Street, BaoAn District, Shenzhen, China |                     |
| VDE0126-1-1, VDE-AR-N4105, IEC61727, IEC62116, UTE C15-712-1, AS4777   |                     |
|    |                     |

|  <b>Solar Grid-tied Inverter</b>  |                     |
|--|---------------------|
| Model No.  | SOFAR 3000TL-G3     |
| Max.DC Input Voltage   | 550V                |
| Operating MPPT Voltage Range   | 50~550V             |
| Max. Input Current   | 12A                 |
| Max. PV Isc  | 15A                 |
| Nominal Grid Voltage   | L/N/PE, 230Vac      |
| Max. Output Current  | 14.5A               |
| Nominal Grid Frequency   | 50/60Hz             |
| Max. Output Power  | 3000VA              |
| Power Factor   | 1(adjustable+/-0.8) |
| Ingress protection   | IP65                |
| Operating Temperature Range  | -30~+60°C           |
| Topology   | Non-isolated        |
| Protective Class   | Class I             |
| Manufacturer:Shenzhen SOFARSOLAR Co., Ltd.<br>Address: 401, Building 4, AnTongDa Industrial Park, District 68, XingDong Community, XinAn Street, BaoAn District, Shenzhen, China |                     |
| VDE0126-1-1, VDE-AR-N4105, IEC61727, IEC62116, UTE C15-712-1, AS4777   |                     |
|   |                     |

|  <b>Solar Grid-tied Inverter</b>  |                     |
|--|---------------------|
| Model No.  | SOFAR 3300TL-G3     |
| Max.DC Input Voltage   | 550V                |
| Operating MPPT Voltage Range   | 50~550V             |
| Max. Input Current   | 12A                 |
| Max. PV Isc  | 15A                 |
| Nominal Grid Voltage   | L/N/PE, 230Vac      |
| Max. Output Current  | 16A                 |
| Nominal Grid Frequency   | 50/60Hz             |
| Max. Output Power  | 3300VA              |
| Power Factor   | 1(adjustable+/-0.8) |
| Ingress protection   | IP65                |
| Operating Temperature Range  | -30~+60°C           |
| Topology   | Non-isolated        |
| Protective Class   | Class I             |
| Manufacturer:Shenzhen SOFARSOLAR Co., Ltd.<br>Address: 401, Building 4, AnTongDa Industrial Park, District 68, XingDong Community, XinAn Street, BaoAn District, Shenzhen, China |                     |
| VDE0126-1-1, VDE-AR-N4105, IEC61727, IEC62116, UTE C15-712-1, AS4777   |                     |
|    |                     |

Note:



General product information:



## 8. Technical data

### Outlines of this chapter

This topic lists the technical specifications for all SOFAR 1.1K~3.3KTL-G3 inverters.

### 8.1. Input parameters (DC)

| Technical Data                           | SOFAR<br>1100TL-<br>G3 | SOFAR<br>1600TL-<br>G3 | SOFAR<br>2200TL-<br>G3 | SOFAR<br>2700TL-<br>G3 | SOFAR<br>3000TL-<br>G3 | SOFAR<br>3300TL-<br>G3 |
|--|------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|
| Max.DC power                             | 1500W                  | 2200W                  | 3000W                  | 3700W                  | 4100W                  | 4500W                  |
| Max.Input voltage                        | 500V                   |                        |                        | 550V                   |                        |                        |
| Anx Start-up<br>voltage                  | 60V                    |                        |                        |                        |                        |                        |
| Start-up input<br>voltage                | 70V                    |                        |                        |                        |                        |                        |
| MPPT voltage range                       | 50-500V                |                        |                        | 50-550V                |                        |                        |
| Rated input voltage                      | 360V                   |                        |                        |                        |                        |                        |
| Full load DC<br>voltage range            | 110-450V               | 150-450V               | 200-450V               | 250-500V               | 275-500V               | 300-500V               |
| Max. Input current                       | 12A                    |                        |                        |                        |                        |                        |
| Input short circuit<br>current           | 15A                    |                        |                        |                        |                        |                        |
| Number of MPPT/<br>Number of DC<br>input | 1/1                    |                        |                        |                        |                        |                        |
| Input terminal type                      | MC4/H4                 |                        |                        |                        |                        |                        |



SOFAR 1.1K~3.3KTL-G3

User manual

## 8.2. Output parameters (AC)

| Technical Data         | SOFAR<br>1100TL-<br>G3                              | SOFAR<br>1600TL-<br>G3 | SOFAR<br>2200TL-<br>G3 | SOFAR<br>2700TL-<br>G3 | SOFAR<br>3000TL-<br>G3 | SOFAR<br>3300TL-<br>G3 |
|------------------------|---|------------------------|------------------------|------------------------|------------------------|------------------------|
| Rated Output power     | 1100W   | 1600W                  | 2200W                  | 2700W                  | 3000W                  | 3300W                  |
| Max. Output power      | 1100VA  | 1600VA                 | 2200VA                 | 2700VA                 | 3000VA                 | 3300VA                 |
| Rated Output current   | 4.8A  | 7A                     | 9.6A                   | 11.8A                  | 13A                    | 14.3A                  |
| Max. Output current    | 5.3A  | 7.7A                   | 10.6A                  | 13A                    | 14.5A                  | 16A                    |
| Nominal grid voltage   | L/N/PE, 220Vac 230Vac 240Vac                        |                        |                        |                        |                        |                        |
| Grid voltage range     | 180-276Vac( According to local grid standard )      |                        |                        |                        |                        |                        |
| Nominal grid frequency | 50Hz/60Hz   |                        |                        |                        |                        |                        |
| Grid frequency range   | 45~55Hz/54~66Hz( According to local grid standard ) |                        |                        |                        |                        |                        |
| THDi                   | <3%   |                        |                        |                        |                        |                        |
| Power factor           | 1 default( +/-0.8 adjustable)                       |                        |                        |                        |                        |                        |

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### Block diagram of the utility interactive inverter:

The solar inverter converts DC voltage into AC voltage.

The EUT has not testing and evaluated of the clause 5.7 Evidence of PAV,E –Control.

The input and output are protected by Varistors to Earth. The unit is providing EMC filtering at the output toward mains. The unit does not provide galvanic separation from input to output (transformerless). The output is switched off redundant by the high power switching bridge and a two relays. This assures that the opening of the output circuit will also operate in case of one error.

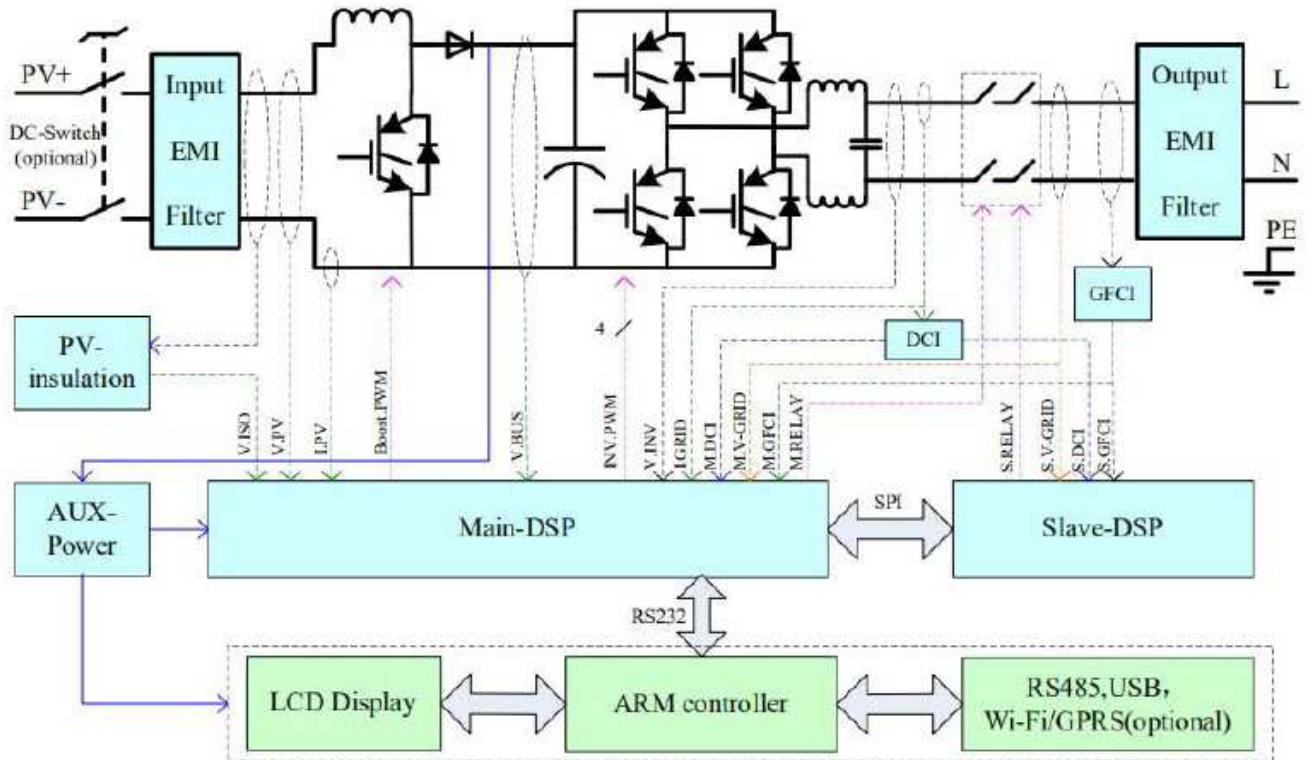


Figure 1 – Block diagram

Description of the electrical circuit: (Figure 1):

The internal control is redundant built. It consists of Microcontroller main DSP(U34) and Slave DSP(U03).

The man DSP (U34) control the relays by switching signals; measures the PV voltage, PV current, Bus voltage, grid voltage, frequency, AC current with injected DC and the array insulation resistance to ground. In addition it tests the current sensors and the RCMU circuit before each start up.

The Slave DSP (U03) is measures the grid voltage, grid frequency, DCI and residual current, also can switch off the relays independently, and communicate with the CPU1 (U100) each other.

The current is measured by a current sensor. The AC current signal and the injected DC current signal are sent to the main DSP(U03). The Slave DSP (U03) tests and calibrates before each start up all current sensors.

The unit provides two relays in series in all output conductors. When single fault applied to one relay, alarm an error code in display panel, another redundant relay provides basic insulation maintained between the PV array and the mains. All the relays are tested before each start up.

### Differences of the models in the series:

The models SOFAR 1100TL-G3, SOFAR 1600TL-G3, SOFAR 2200TL-G3, SOFAR 2700TL-G3, SOFAR 3000TL-G3 and SOFAR 3300TL-G3 are completely identical hardware platform and control system which to each other except the output power derated by software.

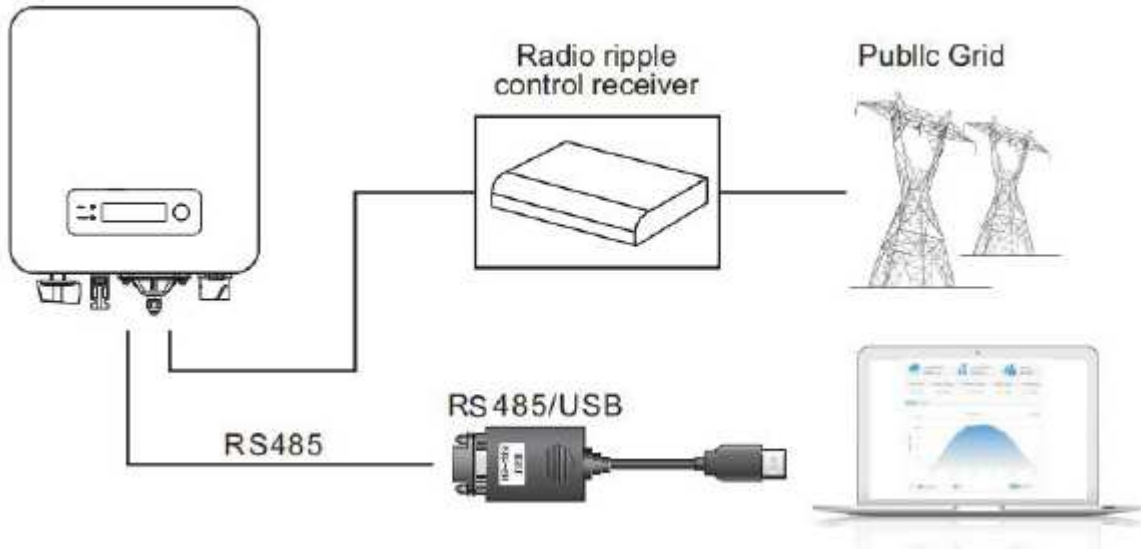
### The product was tested on:

Hardware version: V1.00

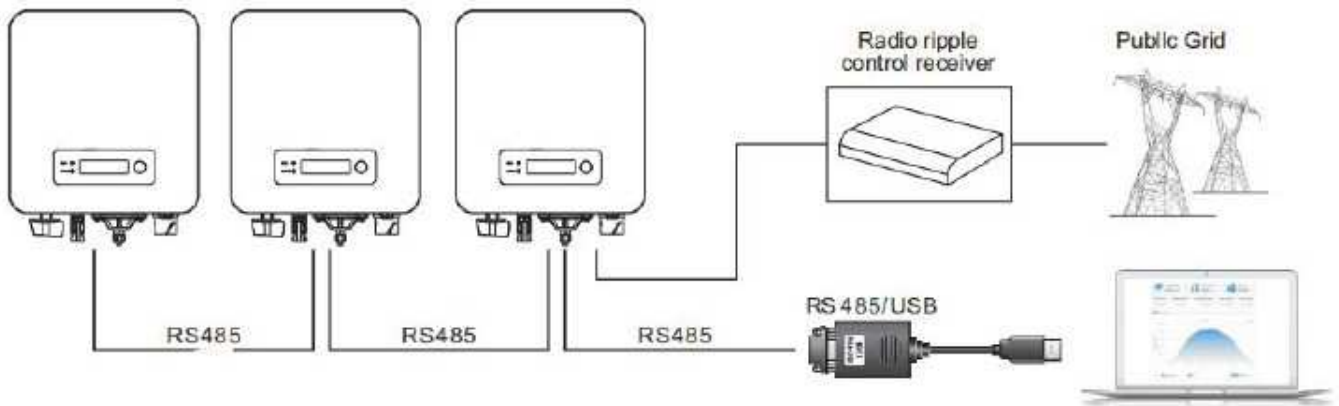
Software version: V2.60

**Description of the remote control in a typical installation:**

Inverter support RS485 communication and WIFI communication.



(a) Single unit monitoring RS485 connection overview



(b) Multi unit monitoring RS485 connection overview



(c) wireless connection overview

**Figure 2 – Scheme of an installation**

**Description of the connection to the ripple control receiver:**

N/A

# Test Results

| <b>DIN VDE V 0124-100</b> |   |                        |                |
|---------------------------|---|------------------------|----------------|
| <b>Clause</b>             | <b>Requirement – Test</b>                                       | <b>Result – Remark</b> | <b>Verdict</b> |
| 5.2                       | Evidence of permissible network perturbations                   |                        | <b>P</b>       |
| 5.3                       | Evidence of symmetry behaviour of inverters                     |                        | <b>N/A</b>     |
| 5.4                       | Evidence of the behaviour of the generating unit on the network |                        | <b>P</b>       |
| 5.5                       | NS-protection   |                        | <b>P</b>       |
| 5.6                       | Connecting conditions and synchronization                       |                        | <b>P</b>       |
| 5.7                       | Evidence of $P_{AV,E}$ -Control                                 |                        | <b>N/A</b>     |
| 5.8                       | Evidence dynamic grid support                                   |                        | <b>P</b>       |
| 5.9                       | Test of Ancillary Unit  |                        | <b>N/A</b>     |

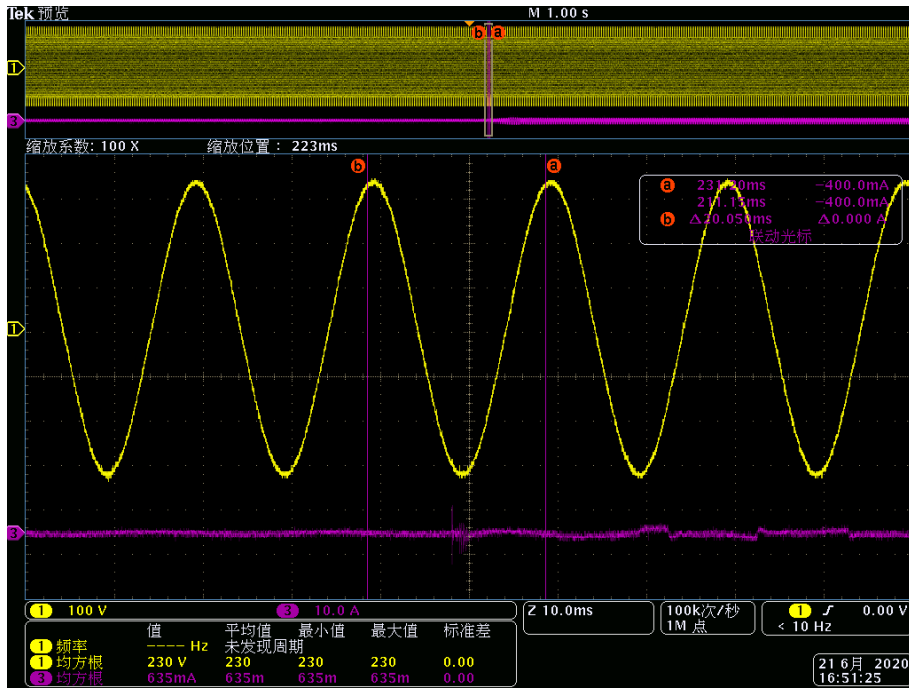
| <b>DIN VDE V 0124-100</b> |   |                        |                |
|---------------------------|---|------------------------|----------------|
| <b>Clause</b>             | <b>Requirement – Test</b>   | <b>Result – Remark</b> | <b>Verdict</b> |
| <b>5.2</b>                | <b>Evidence of permissible network perturbations</b>                        |                        |                |
| 5.2.1                     | General   |                        | <b>P</b>       |
| 5.2.2                     | Rapid voltage changes   |                        | <b>P</b>       |
| 5.2.3                     | Flicker   |                        | <b>P</b>       |
| 5.2.4                     | Harmonics and interharmonics  |                        | <b>p</b>       |
| 5.2.4.1 a)                | Test Harmonics DIN EN 61000-3-2 ( $\leq 16$ A per Phase)                    |                        | <b>P</b>       |
| 5.2.4.1 a)                | Test Harmonics DIN EN 61000-3-12 ( $\geq 16$ A and $\leq 75$ A per Phase)   |                        | <b>P</b>       |
| 5.2.4.1 b)                | Test Harmonics and interharmonics DIN EN 61000-4-7 ( $\geq 75$ A per Phase) |                        | <b>N/A</b>     |
| 5.2.5                     | Commutation   |                        | <b>N/A</b>     |
| 5.2.6                     | Feed in of DC current   |                        | <b>P</b>       |



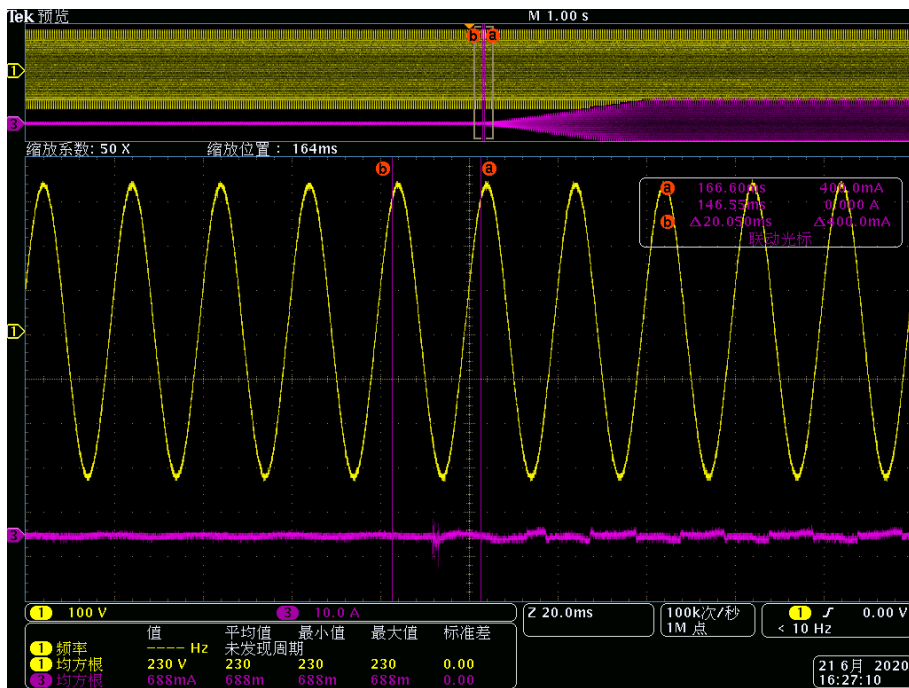
| 5.2.1   | General | P |
|---|---------|---|
| <p>The electrical installations of the customer system shall be planned, constructed and operated so that reactions to the network operator's network and to the systems of other customers are permanently reduced to a permissible minimum. Should interfering reactions on the network operator's network occur nonetheless, the customer shall apply measures to his system that are to be coordinated with the network operator. The network operator is entitled to disconnect the power generation system concerned from the network until the deficiencies are corrected.</p> <p><u>System perturbations are defined as:</u></p> <ul style="list-style-type: none"><li>- Rapid voltage changes</li><li>- Flicker</li><li>- Harmonics, interharmonics and higher frequencies (up to 9 kHz)</li></ul> |         |   |

| 5.2.2  | Rapid voltage changes |        |        |     |     |     |     |     |     | P |
|--|-----------------------|--------|--------|-----|-----|-----|-----|-----|-----|---|
| <p>The purpose of the test is to determine <math>k_i</math> and <math>k_{imax}</math>.</p> <p>The following three cases must be tested (where applicable).</p> <ul style="list-style-type: none"> <li>- Switch-on for any capacity</li> <li>- Unfavourable case when switching the generator step</li> <li>- Switch-on for nominal capacity</li> </ul> <p>Note: For PV-plants the inverter is the generator</p> <ul style="list-style-type: none"> <li>- Switch-off for nominal capacity (no emergency shutdown, but operative shutdown)</li> </ul> <p>If the manufacturer knows more critical cases (e.g. different <math>\cos \varphi</math> parameters) then these additional have to be tested</p> |                       |        |        |     |     |     |     |     |     |   |
| <b>Test conditions:</b>  |                       |        |        |     |     |     |     |     |     |   |
| Frequency: 50 Hz $\pm$ 0,5%  |                       |        |        |     |     |     |     |     |     |   |
| THD of the voltage supply: $\leq$ 3 %  |                       |        |        |     |     |     |     |     |     |   |
| Voltage rise of the PGU at 100 P <sub>E<sub>max</sub></sub> %: $\leq$ 3 %  |                       |        |        |     |     |     |     |     |     |   |
| <b>Switch-on for any capacity (10% P<sub>E<sub>max</sub></sub>)</b>  |                       |        |        |     |     |     |     |     |     |   |
| Phase  | L1                    |        |        | L2  |     |     | L3  |     |     |   |
| Single period effective values of the current [A]  | 0,633                 | 0,635  | 0,590  | N/A | N/A | N/A | N/A | N/A | N/A |   |
| Single period effective values of the voltage [V]  | 230,00                | 230,00 | 230,00 | N/A | N/A | N/A | N/A | N/A | N/A |   |
| $k_i$ value [1]  | 0,633                 | 0,635  | 0,590  | N/A | N/A | N/A | N/A | N/A | N/A |   |
| $k_{imax}$ value [1]   | 0,635                 |        |        |     |     |     |     |     |     |   |
| <b>Unfavourable case when switching the generator step (not necessary for electronic inverter)</b>   |                       |        |        |     |     |     |     |     |     |   |
| Phase  | L1                    |        |        | L2  |     |     | L3  |     |     |   |
| Single period effective values of the current [A]  | N/A                   | N/A    | N/A    | N/A | N/A | N/A | N/A | N/A | N/A |   |
| Single period effective values of the voltage [V]  | N/A                   | N/A    | N/A    | N/A | N/A | N/A | N/A | N/A | N/A |   |
| $k_i$ value [1]  | N/A                   | N/A    | N/A    | N/A | N/A | N/A | N/A | N/A | N/A |   |
| $k_{imax}$ value [1]   | N/A                   |        |        |     |     |     |     |     |     |   |
| <b>Switch-on for nominal capacity</b>  |                       |        |        |     |     |     |     |     |     |   |
| Phase  | L1                    |        |        | L2  |     |     | L3  |     |     |   |
| Single period effective values of the current [A]  | 0,624                 | 0,688  | 0,672  | N/A | N/A | N/A | N/A | N/A | N/A |   |
| Single period effective values of the voltage [V]  | 231,00                | 230,00 | 230,00 | N/A | N/A | N/A | N/A | N/A | N/A |   |
| $k_i$ value [1]  | 0,075                 | 0,083  | 0,081  | N/A | N/A | N/A | N/A | N/A | N/A |   |
| $k_{imax}$ value [1]   | 0,083                 |        |        |     |     |     |     |     |     |   |

Switch-on for any capacity (10%  $P_{Emax}$ ): SOFAR 3300TL-G3



Switch-on for any capacity (100%  $P_{Emax}$ ): SOFAR 3300TL-G3





| Switch-off for nominal capacity  |        |        |        |     |     |     |     |     |     |
|--|--------|--------|--------|-----|-----|-----|-----|-----|-----|
| Phase  | L1     |        |        | L2  |     |     | L3  |     |     |
| Single period effective values of the current [A]  | 9,34   | 9,66   | 9,99   | N/A | N/A | N/A | N/A | N/A | N/A |
| Single period effective values of the voltage [V]  | 228,00 | 228,00 | 228,00 | N/A | N/A | N/A | N/A | N/A | N/A |
| $k_i$ value [1]  | 0,376  | 0,389  | 0,402  | N/A | N/A | N/A | N/A | N/A | N/A |
| $k_{imax}$ value [1]   | 0,402  |        |        |     |     |     |     |     |     |
| Grid Frequency [Hz]  |        |        |        |     |     |     |     |     |     |
| 50,00  |        |        |        |     |     |     |     |     |     |
| Grid voltage [V]   |        |        |        |     |     |     |     |     |     |
| 230,00   |        |        |        |     |     |     |     |     |     |
| Rated current $I_r$ [A]  |        |        |        |     |     |     |     |     |     |
| 14,348   |        |        |        |     |     |     |     |     |     |
| Highest $k_{imax}$ value for all switching operations [1]  |        |        |        |     |     |     |     |     |     |
| 0,635  |        |        |        |     |     |     |     |     |     |
| <b>Note:</b>   |        |        |        |     |     |     |     |     |     |
| Limits:  |        |        |        |     |     |     |     |     |     |
| $k_{imax} = 1,2$ for synchronous generators with fine synchronization, converter; (electronic inverter)  |        |        |        |     |     |     |     |     |     |
| $k_{imax} = 4$ for asynchronous generators, which are switched on at 95% to 105% of their synchronous speed, if no further details are available regarding the type of current limitation. With regard to short-term compensation processes, the condition mentioned below for very short voltage changes must also be observed. |        |        |        |     |     |     |     |     |     |
| $k_{imax} = 8$ for asynchronous generators that are powered up by the network if $I_a$ is unknown.   |        |        |        |     |     |     |     |     |     |
| (I <sub>a</sub> = starting current)  |        |        |        |     |     |     |     |     |     |
| The tests had been performed on the SOFAR 3300TL-G3 is valid for the SOFAR 1100TL-G3, SOFAR 1600TL-G3, SOFAR 2200TL-G3, SOFAR 2700TL-G3 and SOFAR 3000TL-G3 since it is same as in hardware and just power derated by software.  |        |        |        |     |     |     |     |     |     |

|  |                |   |          |                  |
|--|----------------|---|----------|------------------|
| <b>5.2.3</b>   | <b>Flicker</b> | <b>P</b>  |          |                  |
| <p>These tests are designed to provide evidence that the requirements of VDE-AR-N 4100:2109-04 are met.</p>  |                |   |          |                  |
| <p>Adherence to the thresholds for flicker must be verified as followed:</p> <ul style="list-style-type: none"> <li>- For nominal currents <math>\leq 16</math> A per conductor to DIN EN 61000-3-3 (VDE 0838-3)</li> <li>- For nominal currents <math>&gt; 16</math> A and <math>\leq 75</math> A per conductor to DIN EN 61000-3-11 (VDE 0838-11)</li> </ul> |                |   |          |                  |
| <b>Test conditions:</b>  |                |   |          |                  |
| Voltage: 86% $U_n$ to 109% $U_n$   |                |   |          |                  |
| Frequency: 50 Hz $\pm$ 0,5%  |                |   |          |                  |
| THD of the voltage supply: $\leq 3$ %  |                |   |          |                  |
| Voltage rise of the PGU at 100% $P_{Emax}$ : $\leq 3$ %  |                |   |          |                  |
| <b>SOFAR 1100TL-G3</b>   |                |   |          |                  |
| <b>Flicker to DIN EN 61000-3-3 (VDE 0838-3) or DIN EN 61000-3-11 (VDE 0838-11) for generator units <math>\leq 75</math> A</b>  |                |   |          |                  |
| Grid impedance DIN EN 61000-3-3 (VDE 0838-3) [ $\Omega$ ]:   |                | $R_A = 0,24\Omega$ $jX_A = 0,15\Omega$ / $R_N = 0,16\Omega$ $jX_N = 0,10\Omega$ ( $R_n$ and $jX_n$ only for single-phase units used!) |          |                  |
| Output voltage of the impedance network [V]  |                | 230   |          |                  |
| Flicker to:  | Result:        |   |          |                  |
|  | $P_{It}$       | $P_{St}$ dc%  |          |                  |
| DIN EN 61000-3-3   | See below      |   |          |                  |
| No.  | dc[%]          | dmax[%]   | d(t)[ms] | Pst              |
| 1  | 0.00           | 0.00  | 0.00     | 0.07             |
| 2  | 0.00           | 0.00  | 0.00     | 0.07             |
| 3  | 0.00           | 0.00  | 0.00     | 0.07             |
| 4  | 0.00           | 0.00  | 0.00     | 0.07             |
| 5  | 0.00           | 0.00  | 0.00     | 0.07             |
| 6  | 0.00           | 0.00  | 0.00     | 0.07             |
| 7  | 0.00           | 0.00  | 0.00     | 0.07             |
| 8  | 0.00           | 0.00  | 0.00     | 0.07             |
| 9  | 0.00           | 0.00  | 0.00     | 0.07             |
| 10   | 0.00           | 0.00  | 0.00     | 0.07             |
| 11   | 0.00           | 0.00  | 0.00     | 0.07             |
| 12   | 0.00           | 0.00  | 0.00     | 0.07             |
|  |                |   |          | $P_{It}$<br>0.07 |
| SOFAR 1100TL-G3  |                |   |          |                  |

|               | dc[%]            | dmax[%]          | d(t)[ms]                     | Pst              | Plt                        |
|---------------|------------------|------------------|------------------------------|------------------|----------------------------|
| <b>Limit</b>  | <b>3.30</b>      | <b>4.00</b>      | <b>500</b><br><b>3.30(%)</b> | <b>1.00</b>      | <b>0.65</b><br><b>N:12</b> |
| <b>No. 1</b>  | <b>0.00 Pass</b> | <b>0.00 Pass</b> | <b>0 Pass</b>                | <b>0.07 Pass</b> |                            |
| <b>2</b>      | <b>0.44 Pass</b> | <b>0.47 Pass</b> | <b>0 Pass</b>                | <b>0.09 Pass</b> |                            |
| <b>3</b>      | <b>0.00 Pass</b> | <b>0.00 Pass</b> | <b>0 Pass</b>                | <b>0.07 Pass</b> |                            |
| <b>4</b>      | <b>0.00 Pass</b> | <b>0.00 Pass</b> | <b>0 Pass</b>                | <b>0.07 Pass</b> |                            |
| <b>5</b>      | <b>0.00 Pass</b> | <b>0.00 Pass</b> | <b>0 Pass</b>                | <b>0.07 Pass</b> |                            |
| <b>6</b>      | <b>0.00 Pass</b> | <b>0.00 Pass</b> | <b>0 Pass</b>                | <b>0.07 Pass</b> |                            |
| <b>7</b>      | <b>0.00 Pass</b> | <b>0.00 Pass</b> | <b>0 Pass</b>                | <b>0.07 Pass</b> |                            |
| <b>8</b>      | <b>0.00 Pass</b> | <b>0.00 Pass</b> | <b>0 Pass</b>                | <b>0.07 Pass</b> |                            |
| <b>9</b>      | <b>0.00 Pass</b> | <b>0.00 Pass</b> | <b>0 Pass</b>                | <b>0.07 Pass</b> |                            |
| <b>10</b>     | <b>0.00 Pass</b> | <b>0.00 Pass</b> | <b>0 Pass</b>                | <b>0.07 Pass</b> |                            |
| <b>11</b>     | <b>0.00 Pass</b> | <b>0.00 Pass</b> | <b>0 Pass</b>                | <b>0.07 Pass</b> |                            |
| <b>12</b>     | <b>0.05 Pass</b> | <b>0.18 Pass</b> | <b>0 Pass</b>                | <b>0.07 Pass</b> |                            |
| <b>Result</b> | <b>Pass</b>      | <b>Pass</b>      | <b>Pass</b>                  | <b>Pass</b>      | <b>0.07 Pass</b>           |

SOFAR 3300TL-G3

**Assessment criterion:**

Long-term flicker strength Plt to DIN EN 61000-3-3 (VDE 0838-3) or DIN EN 61000-3-11 must be  $\leq 0,5$ .

Determination of the flicker coefficient:

$$c_{\psi_k} = P_{st} \times (S_k / P_n)$$

where  $S_k$  is the short-circuit power of the network standby element (during the determination of the appropriate  $P_{st}$  values)

The value for the network standby element must be determined separately with measurements for rated currents > 75 A.

**SOFAR 1100TL-G3**

**Flicker for rated currents  $\leq 75A$  to DIN EN 61000-3-3 (VDE 0838-3) / DIN EN 61000-3-11 (VDE 0838-11)**

|                                 |       |
|---------------------------------|-------|
| Grid impedance angle $\psi_k$   | 32°   |
| Flicker coefficient $c(\psi_k)$ | 1,480 |

**SOFAR 3300TL-G3**

**Flicker for rated currents  $\leq 75A$  to DIN EN 61000-3-3 (VDE 0838-3) / DIN EN 61000-3-11 (VDE 0838-11)**

|                                 |       |
|---------------------------------|-------|
| Grid impedance angle $\psi_k$   | 32°   |
| Flicker coefficient $c(\psi_k)$ | 1,900 |

**Assessment criterion:**

Long-term flicker strength:  $P_{lt} \leq 0,5$

**Note:**

The test had been performed on the model SOFAR 3300TL-G3 and SOFAR 1100TL-G3, the test results are valid for the SOFAR 1600TL-G3, SOFAR 2200TL-G3, SOFAR 2700TL-G3, SOFAR 3000TL-G3 since it is identical in hardware and software.

| 5.2.4.1 a)                      | Test Harmonics DIN EN 61000-3-2 ( $\leq 16$ A per Phase) |                 |                  |                                    |                   |                 | P                |
|---------------------------------|--|-----------------|------------------|------------------------------------|-------------------|-----------------|------------------|
| <b>SOFAR 1100TL-G3</b>          |  |                 |                  |                                    |                   |                 |                  |
| <b>Phase</b>                    | <b>L1</b>  |                 | <b>L2</b>        |                                    | <b>L3</b>         |                 |                  |
| <b>Power Level</b>              | <b>100%</b>  |                 | <b>100%</b>      |                                    | <b>100%</b>       |                 |                  |
| <b>AC Power [kW]</b>            | 1,098  |                 | N/A              |                                    | N/A               |                 |                  |
| <b>AC Voltage [V]</b>           | 230,30   |                 | N/A              |                                    | N/A               |                 |                  |
| <b>AC Current [A]</b>           | 4,773  |                 | N/A              |                                    | N/A               |                 |                  |
| <b>Frequency [Hz]</b>           | 50,00  |                 | N/A              |                                    | N/A               |                 |                  |
| <b>THD [%]</b>                  | 1,17   |                 | N/A              |                                    | N/A               |                 |                  |
| <b>Order</b>                    | <b>Measure[A]</b>  | <b>Limit[A]</b> | <b>Margin[%]</b> | <b>Order</b>                       | <b>Measure[A]</b> | <b>Limit[A]</b> | <b>Margin[%]</b> |
| 1                               | 4.7727   |                 |                  | 2                                  | 0.0134            | 1.0800          | 98.8             |
| 3                               | 0.0267   | 2.3000          | 98.8             | 4                                  | 0.0116            | 0.4300          | 97.3             |
| 5                               | 0.0130   | 1.1400          | 98.9             | 6                                  | 0.0110            | 0.3000          | 96.3             |
| 7                               | 0.0118   | 0.7700          | 98.5             | 8                                  | 0.0102            | 0.2300          | 95.6             |
| 9                               | 0.0120   | 0.4000          | 97.0             | 10                                 | 0.0091            | 0.1840          | 95.0             |
| 11                              | 0.0125   | 0.3300          | 96.2             | 12                                 | 0.0088            | 0.1533          | 94.3             |
| 13                              | 0.0127   | 0.2100          | 93.9             | 14                                 | 0.0081            | 0.1314          | 93.9             |
| 15                              | 0.0141   | 0.1500          | 90.6             | 16                                 | 0.0079            | 0.1150          | 93.1             |
| 17                              | 0.0141   | 0.1324          | 89.3             | 18                                 | 0.0080            | 0.1022          | 92.2             |
| 19                              | 0.0135   | 0.1184          | 88.6             | 20                                 | 0.0065            | 0.0920          | 92.9             |
| 21                              | 0.0133   | 0.1071          | 87.6             | 22                                 | 0.0062            | 0.0836          | 92.5             |
| 23                              | 0.0132   | 0.0978          | 86.5             | 24                                 | 0.0058            | 0.0767          | 92.5             |
| 25                              | 0.0130   | 0.0900          | 85.6             | 26                                 | 0.0054            | 0.0708          | 92.3             |
| 27                              | 0.0126   | 0.0833          | 84.9             | 28                                 | 0.0054            | 0.0657          | 91.8             |
| 29                              | 0.0124   | 0.0776          | 84.0             | 30                                 | 0.0050            | 0.0613          | 91.8             |
| 31                              | 0.0119   | 0.0726          | 83.6             | 32                                 | 0.0047            | 0.0575          | 91.8             |
| 33                              | 0.0114   | 0.0682          | 83.2             | 34                                 | 0.0045            | 0.0541          | 91.8             |
| 35                              | 0.0107   | 0.0643          | 83.3             | 36                                 | 0.0044            | 0.0511          | 91.4             |
| 37                              | 0.0102   | 0.0608          | 83.3             | 38                                 | 0.0042            | 0.0484          | 91.4             |
| 39                              | 0.0093   | 0.0577          | 83.8             | 40                                 | 0.0040            | 0.0460          | 91.4             |
| PV-curve simulated according to |  |                 |                  | <b>EN 50530</b>                    |                   |                 |                  |
| Voltage of defined MPP [V]      |  |                 |                  | <b>360V d.c.</b>                   |                   |                 |                  |
| Current of defined MPP [A]      |  |                 |                  | <b>4,0A d.c.</b>                   |                   |                 |                  |
| FFU of PV curve [1]             |  |                 |                  | <b>1</b>                           |                   |                 |                  |
| Impedance [ $\Omega$ ]          |  |                 |                  |                                    |                   |                 |                  |
|                                 |  |                 |                  | Line $R_A = 0,24$ $jX_A = 0,15$    |                   |                 |                  |
|                                 |  |                 |                  | Neutral $R_N = 0,16$ $jX_N = 0,10$ |                   |                 |                  |

| SOFAR 1600TL-G3                 |            |          |           |  |            |          |           |  |  |
|---------------------------------|------------|----------|-----------|--|------------|----------|-----------|--|--|
| Phase                           | L1         |          |           | L2                                       |            |          | L3        |  |  |
| Power Level                     | 100%       |          |           | 100%                                     |            |          | 100%      |  |  |
| AC Power [kW]                   | 1,591      |          |           | N/A                                      |            |          | N/A       |  |  |
| AC Voltage [V]                  | 230,44     |          |           | N/A                                      |            |          | N/A       |  |  |
| AC Current [A]                  | 6,910      |          |           | N/A                                      |            |          | N/A       |  |  |
| Frequency [Hz]                  | 50,00      |          |           | N/A                                      |            |          | N/A       |  |  |
| THD [%]                         | 0,87       |          |           | N/A                                      |            |          | N/A       |  |  |
| Order                           | Measure[A] | Limit[A] | Margin[%] | Order                                    | Measure[A] | Limit[A] | Margin[%] |  |  |
| 1                               | 6.9097     |          |           | 2  | 0.0155     | 1.0800   | 98.6      |  |  |
| 3                               | 0.0314     | 2.3000   | 98.6      | 4  | 0.0127     | 0.4300   | 97.0      |  |  |
| 5                               | 0.0156     | 1.1400   | 98.6      | 6  | 0.0117     | 0.3000   | 96.1      |  |  |
| 7                               | 0.0136     | 0.7700   | 98.2      | 8  | 0.0105     | 0.2300   | 95.4      |  |  |
| 9                               | 0.0140     | 0.4000   | 96.5      | 10                                       | 0.0096     | 0.1840   | 94.8      |  |  |
| 11                              | 0.0132     | 0.3300   | 96.0      | 12                                       | 0.0092     | 0.1533   | 94.0      |  |  |
| 13                              | 0.0141     | 0.2100   | 93.3      | 14                                       | 0.0086     | 0.1314   | 93.4      |  |  |
| 15                              | 0.0151     | 0.1500   | 89.9      | 16                                       | 0.0084     | 0.1150   | 92.7      |  |  |
| 17                              | 0.0152     | 0.1324   | 88.5      | 18                                       | 0.0082     | 0.1022   | 92.0      |  |  |
| 19                              | 0.0134     | 0.1184   | 88.7      | 20                                       | 0.0071     | 0.0920   | 92.3      |  |  |
| 21                              | 0.0130     | 0.1071   | 87.9      | 22                                       | 0.0066     | 0.0836   | 92.1      |  |  |
| 23                              | 0.0123     | 0.0978   | 87.4      | 24                                       | 0.0065     | 0.0767   | 91.5      |  |  |
| 25                              | 0.0120     | 0.0900   | 86.7      | 26                                       | 0.0060     | 0.0708   | 91.6      |  |  |
| 27                              | 0.0115     | 0.0833   | 86.1      | 28                                       | 0.0058     | 0.0657   | 91.2      |  |  |
| 29                              | 0.0115     | 0.0776   | 85.2      | 30                                       | 0.0055     | 0.0613   | 91.1      |  |  |
| 31                              | 0.0114     | 0.0726   | 84.3      | 32                                       | 0.0052     | 0.0575   | 91.0      |  |  |
| 33                              | 0.0108     | 0.0682   | 84.1      | 34                                       | 0.0048     | 0.0541   | 91.1      |  |  |
| 35                              | 0.0105     | 0.0643   | 83.7      | 36                                       | 0.0047     | 0.0511   | 90.8      |  |  |
| 37                              | 0.0101     | 0.0608   | 83.4      | 38                                       | 0.0045     | 0.0484   | 90.7      |  |  |
| 39                              | 0.0094     | 0.0577   | 83.8      | 40                                       | 0.0043     | 0.0460   | 90.6      |  |  |
| PV-curve simulated according to |            |          |           | <b>EN 50530</b>                          |            |          |           |  |  |
| Voltage of defined MPP [V]      |            |          |           | <b>360V d.c.</b>                         |            |          |           |  |  |
| Current of defined MPP [A]      |            |          |           | <b>4,6A d.c.</b>                         |            |          |           |  |  |
| FFU of PV curve [1]             |            |          |           | <b>1</b>                                 |            |          |           |  |  |
| Impedance [ $\Omega$ ]          |            |          |           |  |            |          |           |  |  |
|                                 |            |          |           | Line $R_A = 0,24 \text{ j}X_A = 0,15$    |            |          |           |  |  |
|                                 |            |          |           | Neutral $R_N = 0,16 \text{ j}X_N = 0,10$ |            |          |           |  |  |



| SOFAR 2200TL-G3                 |            |          |           |   |            |          |           |
|---------------------------------|------------|----------|-----------|---|------------|----------|-----------|
| Phase                           | L1         |          |           | L2  |            |          | L3        |
| Power Level                     | 100%       |          |           | 100%  |            |          | 100%      |
| AC Power [kW]                   | 2,197      |          |           | N/A   |            |          | N/A       |
| AC Voltage [V]                  | 230,61     |          |           | N/A   |            |          | N/A       |
| AC Current [A]                  | 9,531      |          |           | N/A   |            |          | N/A       |
| Frequency [Hz]                  | 50,00      |          |           | N/A   |            |          | N/A       |
| THD [%]                         | 0,84       |          |           | N/A   |            |          | N/A       |
| Order                           | Measure[A] | Limit[A] | Margin[%] | Order   | Measure[A] | Limit[A] | Margin[%] |
| 1                               | 9.5304     |          |           | 2   | 0.0220     | 1.0800   | 98.0      |
| 3                               | 0.0475     | 2.3000   | 97.9      | 4   | 0.0146     | 0.4300   | 96.6      |
| 5                               | 0.0273     | 1.1400   | 97.6      | 6   | 0.0133     | 0.3000   | 95.6      |
| 7                               | 0.0240     | 0.7700   | 96.9      | 8   | 0.0126     | 0.2300   | 94.5      |
| 9                               | 0.0219     | 0.4000   | 94.5      | 10  | 0.0115     | 0.1840   | 93.7      |
| 11                              | 0.0203     | 0.3300   | 93.9      | 12  | 0.0098     | 0.1533   | 93.6      |
| 13                              | 0.0178     | 0.2100   | 91.5      | 14  | 0.0094     | 0.1314   | 92.9      |
| 15                              | 0.0167     | 0.1500   | 88.9      | 16  | 0.0090     | 0.1150   | 92.2      |
| 17                              | 0.0152     | 0.1324   | 88.5      | 18  | 0.0090     | 0.1022   | 91.2      |
| 19                              | 0.0139     | 0.1184   | 88.3      | 20  | 0.0078     | 0.0920   | 91.5      |
| 21                              | 0.0136     | 0.1071   | 87.3      | 22  | 0.0076     | 0.0836   | 90.9      |
| 23                              | 0.0125     | 0.0978   | 87.2      | 24  | 0.0071     | 0.0767   | 90.7      |
| 25                              | 0.0120     | 0.0900   | 86.7      | 26  | 0.0068     | 0.0708   | 90.4      |
| 27                              | 0.0111     | 0.0833   | 86.6      | 28  | 0.0067     | 0.0657   | 89.8      |
| 29                              | 0.0111     | 0.0776   | 85.7      | 30  | 0.0062     | 0.0613   | 89.9      |
| 31                              | 0.0113     | 0.0726   | 84.4      | 32  | 0.0062     | 0.0575   | 89.3      |
| 33                              | 0.0098     | 0.0682   | 85.6      | 34  | 0.0059     | 0.0541   | 89.1      |
| 35                              | 0.0103     | 0.0643   | 84.0      | 36  | 0.0057     | 0.0511   | 88.8      |
| 37                              | 0.0100     | 0.0608   | 83.6      | 38  | 0.0056     | 0.0484   | 88.5      |
| 39                              | 0.0090     | 0.0577   | 84.4      | 40  | 0.0053     | 0.0460   | 88.5      |
| PV-curve simulated according to |            |          |           | <b>EN 50530</b>   |            |          |           |
| Voltage of defined MPP [V]      |            |          |           | <b>360V d.c.</b>  |            |          |           |
| Current of defined MPP [A]      |            |          |           | <b>6,5A d.c.</b>  |            |          |           |
| FFU of PV curve [1]             |            |          |           | <b>1</b>  |            |          |           |
| Impedance [ $\Omega$ ]          |            |          |           | Line $R_A = 0,24 \text{ j}X_A = 0,15$<br>Neutral $R_N = 0,16 \text{ j}X_N = 0,10$ |            |          |           |

| SOFAR 2700TL-G3                 |            |          |           |   |            |          |           |
|---------------------------------|------------|----------|-----------|---|------------|----------|-----------|
| Phase                           | L1         |          |           | L2  |            |          | L3        |
| Power Level                     | 100%       |          |           | 100%  |            |          | 100%      |
| AC Power [kW]                   | 2,693      |          |           | N/A   |            |          | N/A       |
| AC Voltage [V]                  | 230,78     |          |           | N/A   |            |          | N/A       |
| AC Current [A]                  | 11,677     |          |           | N/A   |            |          | N/A       |
| Frequency [Hz]                  | 50,00      |          |           | N/A   |            |          | N/A       |
| THD [%]                         | 0,97       |          |           | N/A   |            |          | N/A       |
| Order                           | Measure[A] | Limit[A] | Margin[%] | Order   | Measure[A] | Limit[A] | Margin[%] |
| 1                               | 11.6765    |          |           | 2   | 0.0248     | 1.0800   | 97.7      |
| 3                               | 0.0763     | 2.3000   | 96.7      | 4   | 0.0170     | 0.4300   | 96.0      |
| 5                               | 0.0481     | 1.1400   | 95.8      | 6   | 0.0163     | 0.3000   | 94.6      |
| 7                               | 0.0371     | 0.7700   | 95.2      | 8   | 0.0137     | 0.2300   | 94.0      |
| 9                               | 0.0288     | 0.4000   | 92.8      | 10  | 0.0129     | 0.1840   | 93.0      |
| 11                              | 0.0200     | 0.3300   | 93.9      | 12  | 0.0099     | 0.1533   | 93.6      |
| 13                              | 0.0152     | 0.2100   | 92.8      | 14  | 0.0089     | 0.1314   | 93.2      |
| 15                              | 0.0147     | 0.1500   | 90.2      | 16  | 0.0082     | 0.1150   | 92.9      |
| 17                              | 0.0146     | 0.1324   | 89.0      | 18  | 0.0079     | 0.1022   | 92.3      |
| 19                              | 0.0129     | 0.1184   | 89.1      | 20  | 0.0067     | 0.0920   | 92.7      |
| 21                              | 0.0124     | 0.1071   | 88.5      | 22  | 0.0066     | 0.0836   | 92.1      |
| 23                              | 0.0111     | 0.0978   | 88.6      | 24  | 0.0063     | 0.0767   | 91.8      |
| 25                              | 0.0096     | 0.0900   | 89.3      | 26  | 0.0056     | 0.0708   | 92.1      |
| 27                              | 0.0100     | 0.0833   | 88.0      | 28  | 0.0055     | 0.0657   | 91.6      |
| 29                              | 0.0098     | 0.0776   | 87.4      | 30  | 0.0054     | 0.0613   | 91.3      |
| 31                              | 0.0091     | 0.0726   | 87.5      | 32  | 0.0048     | 0.0575   | 91.7      |
| 33                              | 0.0094     | 0.0682   | 86.2      | 34  | 0.0046     | 0.0541   | 91.5      |
| 35                              | 0.0086     | 0.0643   | 86.6      | 36  | 0.0045     | 0.0511   | 91.3      |
| 37                              | 0.0082     | 0.0608   | 86.6      | 38  | 0.0045     | 0.0484   | 90.8      |
| 39                              | 0.0085     | 0.0577   | 85.3      | 40  | 0.0042     | 0.0460   | 90.9      |
| PV-curve simulated according to |            |          |           | <b>EN 50530</b>   |            |          |           |
| Voltage of defined MPP [V]      |            |          |           | <b>360V d.c.</b>  |            |          |           |
| Current of defined MPP [A]      |            |          |           | <b>8,0A d.c.</b>  |            |          |           |
| FFU of PV curve [1]             |            |          |           | <b>1</b>  |            |          |           |
| Impedance [ $\Omega$ ]          |            |          |           | Line $R_A = 0,24 \text{ j}X_A = 0,15$<br>Neutral $R_N = 0,16 \text{ j}X_N = 0,10$ |            |          |           |

| SOFAR 3300TL-G3                 |            |          |           |   |            |          |           |
|---------------------------------|------------|----------|-----------|---|------------|----------|-----------|
| Phase                           | L1         |          |           | L2  |            | L3       |           |
| Power Level                     | 100%       |          |           | 100%  |            | 100%     |           |
| AC Power [kW]                   | 3,302      |          |           | N/A   |            | N/A      |           |
| AC Voltage [V]                  | 230,99     |          |           | N/A   |            | N/A      |           |
| AC Current [A]                  | 14,305     |          |           | N/A   |            | N/A      |           |
| Frequency [Hz]                  | 50,00      |          |           | N/A   |            | N/A      |           |
| THD [%]                         | 1,41       |          |           | N/A   |            | N/A      |           |
| Order                           | Measure[A] | Limit[A] | Margin[%] | Order   | Measure[A] | Limit[A] | Margin[%] |
| 1                               | 14.3034    |          |           | 2   | 0.0267     | 1.0800   | 97.5      |
| 3                               | 0.1537     | 2.3000   | 93.3      | 4   | 0.0207     | 0.4300   | 95.2      |
| 5                               | 0.0992     | 1.1400   | 91.3      | 6   | 0.0156     | 0.3000   | 94.8      |
| 7                               | 0.0634     | 0.7700   | 91.8      | 8   | 0.0125     | 0.2300   | 94.6      |
| 9                               | 0.0356     | 0.4000   | 91.1      | 10  | 0.0103     | 0.1840   | 94.4      |
| 11                              | 0.0175     | 0.3300   | 94.7      | 12  | 0.0102     | 0.1533   | 93.3      |
| 13                              | 0.0285     | 0.2100   | 86.4      | 14  | 0.0194     | 0.1314   | 85.2      |
| 15                              | 0.0304     | 0.1500   | 79.7      | 16  | 0.0183     | 0.1150   | 84.1      |
| 17                              | 0.0161     | 0.1324   | 87.8      | 18  | 0.0087     | 0.1022   | 91.5      |
| 19                              | 0.0131     | 0.1184   | 88.9      | 20  | 0.0071     | 0.0920   | 92.3      |
| 21                              | 0.0115     | 0.1071   | 89.2      | 22  | 0.0067     | 0.0836   | 92.0      |
| 23                              | 0.0102     | 0.0978   | 89.6      | 24  | 0.0063     | 0.0767   | 91.7      |
| 25                              | 0.0101     | 0.0900   | 88.8      | 26  | 0.0056     | 0.0708   | 92.0      |
| 27                              | 0.0104     | 0.0833   | 87.6      | 28  | 0.0055     | 0.0657   | 91.7      |
| 29                              | 0.0103     | 0.0776   | 86.7      | 30  | 0.0053     | 0.0613   | 91.3      |
| 31                              | 0.0100     | 0.0726   | 86.3      | 32  | 0.0050     | 0.0575   | 91.4      |
| 33                              | 0.0098     | 0.0682   | 85.6      | 34  | 0.0048     | 0.0541   | 91.1      |
| 35                              | 0.0099     | 0.0643   | 84.6      | 36  | 0.0046     | 0.0511   | 90.9      |
| 37                              | 0.0097     | 0.0608   | 84.0      | 38  | 0.0043     | 0.0484   | 91.1      |
| 39                              | 0.0092     | 0.0577   | 84.0      | 40  | 0.0040     | 0.0460   | 91.3      |
| PV-curve simulated according to |            |          |           | <b>EN 50530</b>   |            |          |           |
| Voltage of defined MPP [V]      |            |          |           | <b>360V d.c.</b>  |            |          |           |
| Current of defined MPP [A]      |            |          |           | <b>10,0A d.c.</b>   |            |          |           |
| FFU of PV curve [1]             |            |          |           | <b>1</b>  |            |          |           |
| Impedance [ $\Omega$ ]          |            |          |           | Line $R_A = 0,24 \text{ j}X_A = 0,15$<br>Neutral $R_N = 0,16 \text{ j}X_N = 0,10$ |            |          |           |

| SOFAR 3000TL-G3                 |            |          |           |   |            |          |           |
|---------------------------------|------------|----------|-----------|---|------------|----------|-----------|
| Phase                           | L1         |          | L2        |   | L3         |          |           |
| Power Level                     | 100%       |          | 100%      |   | 100%       |          |           |
| AC Power [kW]                   | 2,989      |          | N/A       |   | N/A        |          |           |
| AC Voltage [V]                  | 230,88     |          | N/A       |   | N/A        |          |           |
| AC Current [A]                  | 12,952     |          | N/A       |   | N/A        |          |           |
| Frequency [Hz]                  | 50,00      |          | N/A       |   | N/A        |          |           |
| THD [%]                         | 1,22       |          | N/A       |   | N/A        |          |           |
| Order                           | Measure[A] | Limit[A] | Margin[%] | Order   | Measure[A] | Limit[A] | Margin[%] |
| 1                               | 12.9514    |          |           | 2   | 0.0221     | 1.0800   | 98.0      |
| 3                               | 0.1124     | 2.3000   | 95.1      | 4   | 0.0157     | 0.4300   | 96.3      |
| 5                               | 0.0740     | 1.1400   | 93.5      | 6   | 0.0132     | 0.3000   | 95.6      |
| 7                               | 0.0529     | 0.7700   | 93.1      | 8   | 0.0112     | 0.2300   | 95.1      |
| 9                               | 0.0357     | 0.4000   | 91.1      | 10  | 0.0098     | 0.1840   | 94.7      |
| 11                              | 0.0211     | 0.3300   | 93.6      | 12  | 0.0085     | 0.1533   | 94.5      |
| 13                              | 0.0199     | 0.2100   | 90.5      | 14  | 0.0079     | 0.1314   | 94.0      |
| 15                              | 0.0171     | 0.1500   | 88.6      | 16  | 0.0077     | 0.1150   | 93.3      |
| 17                              | 0.0173     | 0.1324   | 86.9      | 18  | 0.0076     | 0.1022   | 92.6      |
| 19                              | 0.0148     | 0.1184   | 87.5      | 20  | 0.0064     | 0.0920   | 93.0      |
| 21                              | 0.0124     | 0.1071   | 88.5      | 22  | 0.0063     | 0.0836   | 92.5      |
| 23                              | 0.0106     | 0.0978   | 89.2      | 24  | 0.0061     | 0.0767   | 92.1      |
| 25                              | 0.0097     | 0.0900   | 89.2      | 26  | 0.0053     | 0.0708   | 92.5      |
| 27                              | 0.0102     | 0.0833   | 87.8      | 28  | 0.0051     | 0.0657   | 92.3      |
| 29                              | 0.0098     | 0.0776   | 87.4      | 30  | 0.0050     | 0.0613   | 91.9      |
| 31                              | 0.0092     | 0.0726   | 87.3      | 32  | 0.0046     | 0.0575   | 92.0      |
| 33                              | 0.0091     | 0.0682   | 86.7      | 34  | 0.0045     | 0.0541   | 91.7      |
| 35                              | 0.0088     | 0.0643   | 86.3      | 36  | 0.0044     | 0.0511   | 91.5      |
| 37                              | 0.0084     | 0.0608   | 86.2      | 38  | 0.0042     | 0.0484   | 91.4      |
| 39                              | 0.0083     | 0.0577   | 85.7      | 40  | 0.0039     | 0.0460   | 91.4      |
| PV-curve simulated according to |            |          |           | EN 50530  |            |          |           |
| Voltage of defined MPP [V]      |            |          |           | 360V d.c.   |            |          |           |
| Current of defined MPP [A]      |            |          |           | 9,0A d.c.   |            |          |           |
| FFU of PV curve [1]             |            |          |           | 1   |            |          |           |
| Impedance [ $\Omega$ ]          |            |          |           | Line $R_A = 0,24 \text{ j}X_A = 0,15$<br>Neutral $R_N = 0,16 \text{ j}X_N = 0,10$ |            |          |           |

| 5.2.6   | Feed in of DC current                           |   |                         | P |
|---|---|---|-------------------------|---|
| <b>SOFAR 3300TL-G3</b>  |   |   |                         |   |
| Power Level [% of VA <sub>r</sub> ]   | 30% S <sub>E</sub> max to 40%S <sub>E</sub> max | 60% S <sub>E</sub> max to 70%S <sub>E</sub> max | >95% S <sub>E</sub> max |   |
| AC Power [kVA]  | 1,047   | 1,960   | 3,292                   |   |
| AC Voltage [V]  | 230,6   | 231,1   | 230,9                   |   |
| AC Current [A]  | 4,546   | 8,487   | 14,269                  |   |
| DC Current in AC [A]  | -0,049  | -0,048  | -0,044                  |   |
| DC Current in AC [% of I <sub>r</sub> ]   | -0,342  | -0,335  | -0,307                  |   |
| <b>SOFAR 3300TL-G3</b>  |   |   |                         |   |
| Power Level [% of VA <sub>r</sub> ]   | 30% S <sub>E</sub> max to 40%S <sub>E</sub> max | 60% S <sub>E</sub> max to 70%S <sub>E</sub> max | >95% S <sub>E</sub> max |   |
| AC Power [VA]   | 387   | 720   | 1105                    |   |
| AC Voltage [V]  | 230,33  | 230,57  | 230,87                  |   |
| AC Current [A]  | 1,679   | 3,123   | 4,786                   |   |
| DC Current in AC [A]  | 0,004   | 0,005   | 0,006                   |   |
| DC Current in AC [% of I <sub>r</sub> ]   | 0,086   | 0,105   | 0,120                   |   |
| <b>Test:</b>  |   |   |                         |   |
| <p>The inverter must be used in the adjustment range Test1, Test2 and Test 3. Each test point shall be held for min 5 minutes and I<sub>AC</sub>, U<sub>AC</sub>, I<sub>dc in AC</sub> of each phase has to be recorded. Measurement of I<sub>dc in AC</sub> must be done according to VDE AR-N 4100:2019-04 based on DIN EN 61000-4-7 (VDE-0847-4-7) over 10 fundamental periods.</p>                  |   |   |                         |   |
| <b>Assessment criterion:</b>  |   |   |                         |   |
| <p>An inverter must not feed more than 0,5% of its rated current I<sub>r</sub> or a maximum of 20 mA (the higher value is to be selected) as direct current.</p> <p>The tests had been performed on the SOFAR 3300TL-G3 is valid for the SOFAR 1100TL-G3, SOFAR 1600TL-G3, SOFAR 2200TL-G3, SOFAR 2700TL-G3 and SOFAR 3000TL-G3 since it is same as in hardware and just power derated by software.</p> |   |   |                         |   |

Diagram of Feed in of DC current: SOFAR 3300TL-G3

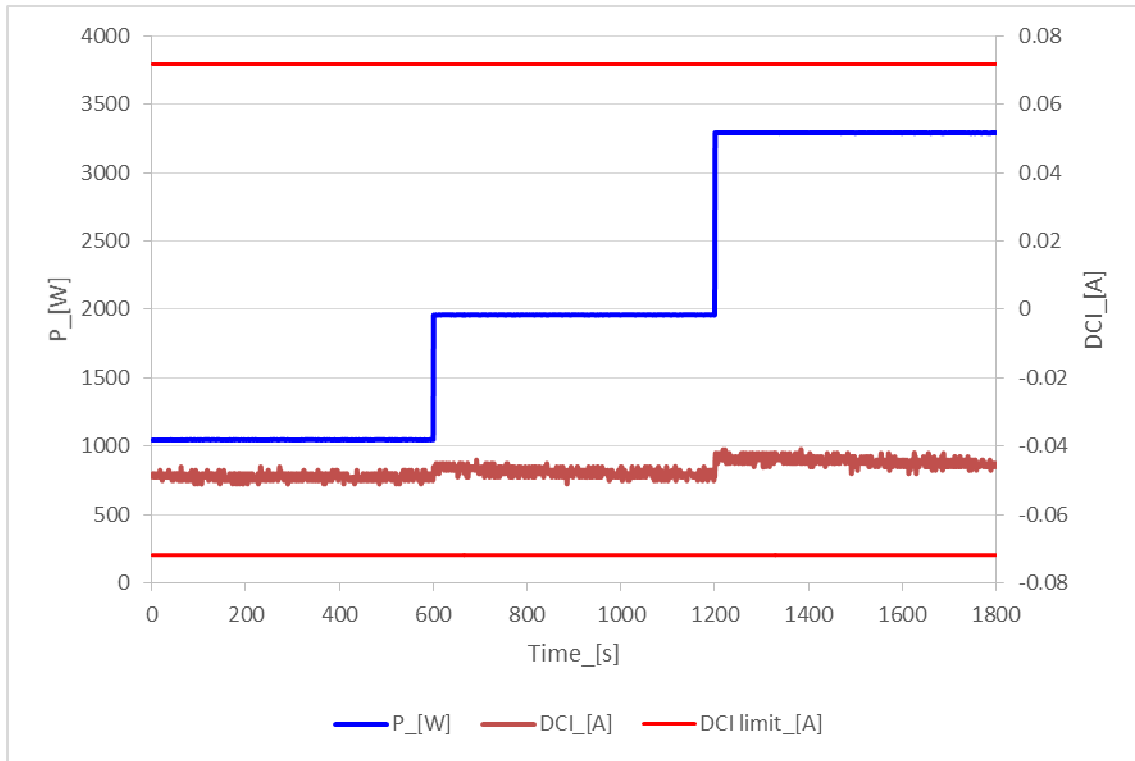
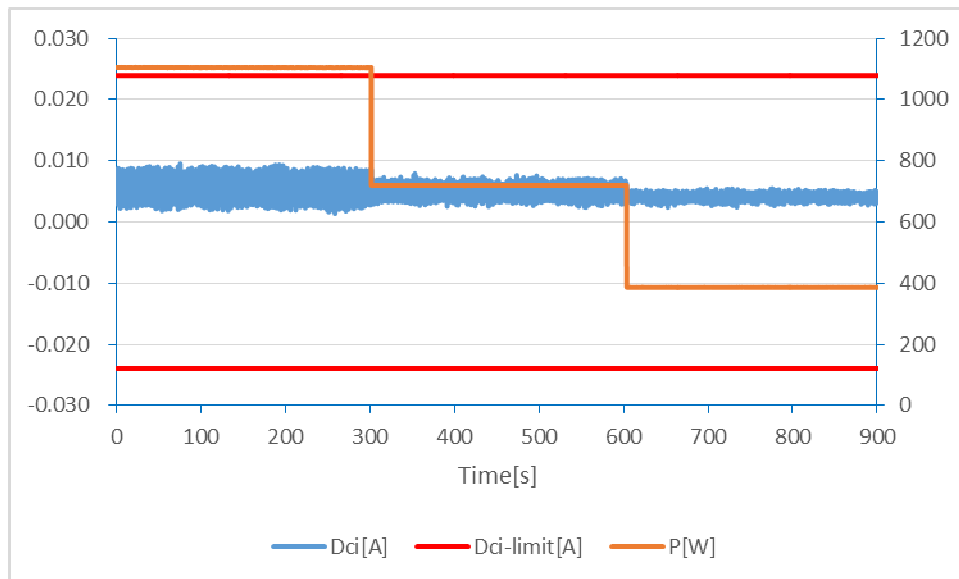


Diagram of Feed in of DC current: SOFAR 1100TL-G3



| <b>5.3 Evidence of symmetry behaviour of inverters</b> |   |                |
|--|---|----------------|
| <b>Clause</b>  | <b>Requirement – Test</b>                             | <b>Verdict</b> |
| <b>5.3.1</b>   | General   | <b>N/A</b>     |
| <b>5.3.2.1</b>   | Calculation of the asymmetry of three-phase inverters | <b>N/A</b>     |
| <b>5.3.2.2.1</b>                                       | Failure of single inverter modules                    | <b>N/A</b>     |
| <b>5.3.2.2.2</b>                                       | Power drop of single inverter modules                 | <b>N/A</b>     |
| <b>5.3.2.3.2</b>                                       | Symmetrical operation with a symmetry device          | <b>N/A</b>     |

| <b>5.4 Evidence of the behaviour of the generating unit on the network</b> |  |                |
|--|--|----------------|
| <b>Clause</b>  | <b>Requirement – Test</b>  | <b>Verdict</b> |
| 5.4.1  | General  | P              |
| 5.4.2  | Measurement of the active and reactive power range                                   | P              |
| 5.4.3.3  | Measurement of setting accuracy  | P              |
| 5.4.3.4  | Measurement of the power gradient  | P              |
| 5.4.3.5  | Measurement Priority Interfaces / Energy Management                                  | N/A            |
| 5.4.4  | Active power feed-in for PGUs at overfrequency                                       | P              |
| 5.4.5  | Active power feed-in of Storage systems for overfrequency                            | N/A            |
| 5.4.6  | Active power feed-in for PGUs at underfrequency                                      | P              |
| 5.4.7  | Active power feed-in for storage systems at underfrequency                           | N/A            |
| 5.4.8  | Static voltage stability / reactive power supply                                     | P              |
| 5.4.8.2  | Tests of the Reactive power / $\cos \varphi$ setting accuracy                        | P              |
|  | The regulating and control behaviour of the reactive power                           | P              |
| 5.4.8.3  | Test of the displacement factor/active power characteristic curve $\cos \varphi$ (P) | P              |
|  | Test 1) for conducted PGUs - Accuracy (characteristic)                               | P              |
|  | Test 2) for conducted PGUs - dynamics  | P              |
|  | Test 3) supply-dependent PGUs - Accuracy (characteristic curve)                      | P              |
|  | Test 4) supply-dependent PGUs - Dynamic  | P              |
| 5.4.8.4.1  | Test of the accuracy of the Q(U) regulation  | P              |
| 5.4.8.4.2  | Test of the dynamics of the Q(U) regulation  | P              |



|   |  |          |
|---|--|----------|
| <b>5.4.1</b>  | <b>General</b><br>(these tests are designed to provide evidence that the requirements of VDE-AR-N 4105:2018-11, 5.7.2.2 are met and to determine the values for $S_{E_{max}}$ and $P_{E_{max}}$ )                                      | <b>P</b> |
| <b>Test Condition:</b>  | <p>The measurements were performed in the testing laboratory at the grid-simulator.</p> <p>Test voltage between 0,9 Un and 1,09 Un with <math>\pm 2\%</math> Un until the test</p> <p>Test frequency: 50 Hz <math>\pm 0,5\%</math></p> |          |
| <p><b>Note:</b><br/>If an examination is required for any other requirements, these apply to this test.</p> |  |          |

| 5.4.2  |                              | Measurement of the active power and reactive power range<br>(these tests are designed to provide evidence that the requirements of VDE-AR-N 4105:2018-11, 5.7.2.2 are met) |                          |                                | P   |
|--|------------------------------|--|--------------------------|--------------------------------|-----|
| Setting values   | cos $\varphi = 1$ :          |  |                          |                                | 1,0 |
|  | cos $\varphi$ over-excited:  |  |                          |                                | 0,9 |
|  | cos $\varphi$ under-excited: |  |                          |                                | 0,9 |
| <b>Test: SOFAR 1100TL-G3</b>   |                              |  |                          |                                |     |
| 600 s mean value   | U [V]                        | $P_{E_{max600\ c}}$ [W]  | $S_{E_{max600\ c}}$ [VA] | cos $\varphi_{E_{max600}}$ [1] |     |
| <b>0,90 <math>U_n</math> at 100% <math>P_{E_{max}}</math></b>                          |                              |  |                          |                                |     |
| cos $\varphi = 1$  | 207,01                       | 1101   | 1107                     | 0,994                          |     |
| cos $\varphi$ max. over-excited  | 207,16                       | 1062   | 1181                     | 0,899                          |     |
| <b>0,95 <math>U_n</math> at 100% <math>P_{E_{max}}</math></b>                          |                              |  |                          |                                |     |
| cos $\varphi$ max. under-excited   | 218,53                       | 1066   | 1184                     | 0,900                          |     |
| <b>1,0 <math>U_n</math> at 100% <math>P_{E_{max}}</math></b>                           |                              |  |                          |                                |     |
| cos $\varphi = 1$  | 229,95                       | 1103   | 1109                     | 0,995                          |     |
| cos $\varphi$ max. under-excited   | 230,00                       | 1069   | 1186                     | 0,901                          |     |
| cos $\varphi$ max. over-excited  | 230,08                       | 1002   | 1110                     | 0,903                          |     |
| <b>1,05 <math>U_n</math> at 100% <math>P_{E_{max}}</math></b>                          |                              |  |                          |                                |     |
| cos $\varphi$ max. over-excited  | 241,49                       | 1079   | 1194                     | 0,904                          |     |
| <b>1,09 <math>U_n</math> at 100% <math>P_{E_{max}}</math></b>                          |                              |  |                          |                                |     |
| cos $\varphi = 1$  | 250,13                       | 1098   | 1103                     | 0,995                          |     |
| cos $\varphi$ max. under-excited   | 250,69                       | 997  | 1102                     | 0,905                          |     |
| <b><math>S_{E_{max600}}</math> and <math>P_{E_{max\ 600}}</math></b>                   |                              |  |                          |                                |     |
| $S_{E_{max600}} = \max(S_{E_{max600\ a}}, S_{E_{max600\ b}}, S_{E_{max600\ c}})$ [VA]  |                              |  | 1194                     |                                |     |
| $P_{E_{max\ 600}} = \max(P_{E_{max600\ a}}, P_{E_{max600\ b}}, P_{E_{max600\ c}})$ [W] |                              |  | 1103                     |                                |     |
| <b>Test: SOFAR 1600TL-G3</b>   |                              |  |                          |                                |     |
| 600 s mean value   | U [V]                        | $P_{E_{max600\ c}}$ [W]  | $S_{E_{max600\ c}}$ [VA] | cos $\varphi_{E_{max600}}$ [1] |     |
| <b>0,90 <math>U_n</math> at 100% <math>P_{E_{max}}</math></b>                          |                              |  |                          |                                |     |
| cos $\varphi = 1$  | 207,08                       | 1601   | 1606                     | 0,997                          |     |
| cos $\varphi$ max. over-excited  | 207,11                       | 1509   | 1677                     | 0,900                          |     |
| <b>0,95 <math>U_n</math> at 100% <math>P_{E_{max}}</math></b>                          |                              |  |                          |                                |     |
| cos $\varphi$ max. under-excited   | 218,58                       | 1518   | 1684                     | 0,901                          |     |
| <b>1,0 <math>U_n</math> at 100% <math>P_{E_{max}}</math></b>                           |                              |  |                          |                                |     |
| cos $\varphi = 1$  | 229,98                       | 1606   | 1611                     | 0,997                          |     |
| cos $\varphi$ max. under-excited   | 230,01                       | 1519   | 1685                     | 0,902                          |     |
| cos $\varphi$ max. over-excited  | 230,00                       | 1437   | 1601                     | 0,897                          |     |



| <b>1,05 U<sub>n</sub> at 100% P<sub>Emax</sub></b>   |        |                            |                             |                              |
|--|--------|----------------------------|-----------------------------|------------------------------|
| cos φ max. over-excited  | 241,53 | 1527                       | 1690                        | 0,903                        |
| <b>1,09 U<sub>n</sub> at 100% P<sub>Emax</sub></b>   |        |                            |                             |                              |
| cos φ = 1  | 250,64 | 1601                       | 1605                        | 0,997                        |
| cos φ max. under-excited   | 250,60 | 1432                       | 1596                        | 0,897                        |
| <b>S<sub>Emax600</sub> and P<sub>Emax 600</sub></b>  |        |                            |                             |                              |
| S <sub>Emax600</sub> = max(S <sub>Emax600 a</sub> ), S <sub>Emax600 b</sub> ), S <sub>Emax600 c</sub> ) [VA] |        | 1690                       |                             |                              |
| P <sub>Emax 600</sub> = max(P <sub>Emax600 a</sub> ), P <sub>Emax600 b</sub> ), P <sub>Emax600 c</sub> ) [W] |        | 1606                       |                             |                              |
| <b>Test: SOFAR 2200TL-G3</b>   |        |                            |                             |                              |
| 600 s mean value   | U [V]  | P <sub>Emax600 c</sub> [W] | S <sub>Emax600 c</sub> [VA] | COS φ <sub>Emax600</sub> [1] |
| <b>0,90 U<sub>n</sub> at 100% P<sub>Emax</sub></b>   |        |                            |                             |                              |
| cos φ = 1  | 207,01 | 2194                       | 2195                        | 0,999                        |
| cos φ max. over-excited  | 207,11 | 2056                       | 2277                        | 0,903                        |
| <b>0,95 U<sub>n</sub> at 100% P<sub>Emax</sub></b>   |        |                            |                             |                              |
| cos φ max. under-excited   | 218,68 | 2062                       | 2284                        | 0,903                        |
| <b>1,0 U<sub>n</sub> at 100% P<sub>Emax</sub></b>  |        |                            |                             |                              |
| cos φ = 1  | 230,47 | 2196                       | 2198                        | 0,999                        |
| cos φ max. under-excited   | 230,13 | 2069                       | 2292                        | 0,903                        |
| cos φ max. over-excited  | 230,08 | 1998                       | 2222                        | 0,899                        |
| <b>1,05 U<sub>n</sub> at 100% P<sub>Emax</sub></b>   |        |                            |                             |                              |
| cos φ max. over-excited  | 241,48 | 2081                       | 2304                        | 0,903                        |
| <b>1,09 U<sub>n</sub> at 100% P<sub>Emax</sub></b>   |        |                            |                             |                              |
| cos φ = 1  | 250,72 | 2197                       | 2199                        | 0,999                        |
| cos φ max. under-excited   | 250,65 | 1991                       | 2215                        | 0,899                        |
| <b>S<sub>Emax600</sub> and P<sub>Emax 600</sub></b>  |        |                            |                             |                              |
| S <sub>Emax600</sub> = max(S <sub>Emax600 a</sub> ), S <sub>Emax600 b</sub> ), S <sub>Emax600 c</sub> ) [VA] |        | 2304                       |                             |                              |
| P <sub>Emax 600</sub> = max(P <sub>Emax600 a</sub> ), P <sub>Emax600 b</sub> ), P <sub>Emax600 c</sub> ) [W] |        | 2197                       |                             |                              |
| <b>Test: SOFAR 2700TL-G3</b>   |        |                            |                             |                              |
| 600 s mean value   | U [V]  | P <sub>Emax600 c</sub> [W] | S <sub>Emax600 c</sub> [VA] | COS φ <sub>Emax600</sub> [1] |
| <b>0,90 U<sub>n</sub> at 100% P<sub>Emax</sub></b>   |        |                            |                             |                              |
| cos φ = 1  | 206,93 | 2686                       | 2687                        | 0,999                        |
| cos φ max. over-excited  | 206,94 | 2485                       | 2756                        | 0,902                        |
| <b>0,95 U<sub>n</sub> at 100% P<sub>Emax</sub></b>   |        |                            |                             |                              |
| cos φ max. under-excited   | 218,56 | 2510                       | 2783                        | 0,902                        |
| <b>1,0 U<sub>n</sub> at 100% P<sub>Emax</sub></b>  |        |                            |                             |                              |
| cos φ = 1  | 231,77 | 2698                       | 2699                        | 0,999                        |
| cos φ max. under-excited   | 230,11 | 2516                       | 2787                        | 0,903                        |



|  |        |                                       |  |  |
|--|--------|---------------------------------------|--|--|
| cos $\phi$ max. over-excited   | 230,03 | 2433                                  | 2705                                   | 0,899  |
| <b>1,05 U<sub>n</sub> at 100% P<sub>E<sub>max</sub></sub></b>  |        |                                       |  |  |
| cos $\phi$ max. over-excited   | 241,55 | 2519                                  | 2790                                   | 0,903  |
| <b>1,09 U<sub>n</sub> at 100% P<sub>E<sub>max</sub></sub></b>  |        |                                       |  |  |
| cos $\phi$ = 1   | 250,71 | 2698                                  | 2699                                   | 0,999  |
| cos $\phi$ max. under-excited  | 250,77 | 2423                                  | 2697                                   | 0,898  |
| <b>S<sub>E<sub>max</sub>600</sub> and P<sub>E<sub>max</sub> 600</sub></b>  |        |                                       |  |  |
| S <sub>E<sub>max</sub>600</sub> = max(S <sub>E<sub>max</sub>600 a</sub> ), S <sub>E<sub>max</sub>600 b</sub> ), S <sub>E<sub>max</sub>600 c</sub> ) [VA] |        |                                       | 2790                                   |  |
| P <sub>E<sub>max</sub> 600</sub> = max(P <sub>E<sub>max</sub>600 a</sub> ), P <sub>E<sub>max</sub>600 b</sub> ), P <sub>E<sub>max</sub>600 c</sub> ) [W] |        |                                       | 2698                                   |  |
| <b>Test: SOFAR 3000TL-G3</b>   |        |                                       |  |  |
| 600 s mean value   | U [V]  | P <sub>E<sub>max</sub>600 c</sub> [W] | S <sub>E<sub>max</sub>600 c</sub> [VA] | COS $\phi$ <sub>E<sub>max</sub>600</sub> [1] |
| <b>0,90 U<sub>n</sub> at 100% P<sub>E<sub>max</sub></sub></b>  |        |                                       |  |  |
| cos $\phi$ = 1   | 206,82 | 2995                                  | 2997                                   | 0,999  |
| cos $\phi$ max. over-excited   | 206,80 | 2767                                  | 3069                                   | 0,902  |
| <b>0,95 U<sub>n</sub> at 100% P<sub>E<sub>max</sub></sub></b>  |        |                                       |  |  |
| cos $\phi$ max. under-excited  | 218,32 | 2785                                  | 3088                                   | 0,902  |
| <b>1,0 U<sub>n</sub> at 100% P<sub>E<sub>max</sub></sub></b>   |        |                                       |  |  |
| cos $\phi$ = 1   | 231,53 | 2991                                  | 2992                                   | 0,999  |
| cos $\phi$ max. under-excited  | 230,78 | 2789                                  | 3097                                   | 0,900  |
| cos $\phi$ max. over-excited   | 230,84 | 2714                                  | 3012                                   | 0,901  |
| <b>1,05 U<sub>n</sub> at 100% P<sub>E<sub>max</sub></sub></b>  |        |                                       |  |  |
| cos $\phi$ max. over-excited   | 241,71 | 2785                                  | 3091                                   | 0,901  |
| <b>1,09 U<sub>n</sub> at 100% P<sub>E<sub>max</sub></sub></b>  |        |                                       |  |  |
| cos $\phi$ = 1   | 250,73 | 2994                                  | 2996                                   | 0,999  |
| cos $\phi$ max. under-excited  | 250,63 | 2696                                  | 2997                                   | 0,899  |
| <b>S<sub>E<sub>max</sub>600</sub> and P<sub>E<sub>max</sub> 600</sub></b>  |        |                                       |  |  |
| S <sub>E<sub>max</sub>600</sub> = max(S <sub>E<sub>max</sub>600 a</sub> ), S <sub>E<sub>max</sub>600 b</sub> ), S <sub>E<sub>max</sub>600 c</sub> ) [VA] |        |                                       | 3097                                   |  |
| P <sub>E<sub>max</sub> 600</sub> = max(P <sub>E<sub>max</sub>600 a</sub> ), P <sub>E<sub>max</sub>600 b</sub> ), P <sub>E<sub>max</sub>600 c</sub> ) [W] |        |                                       | 2995                                   |  |
| <b>Test: SOFAR 3300TL-G3</b>   |        |                                       |  |  |
| 600 s mean value   | U [V]  | P <sub>E<sub>max</sub>600 c</sub> [W] | S <sub>E<sub>max</sub>600 c</sub> [VA] | COS $\phi$ <sub>E<sub>max</sub>600</sub> [1] |
| <b>0,90 U<sub>n</sub> at 100% P<sub>E<sub>max</sub></sub></b>  |        |                                       |  |  |
| cos $\phi$ = 1   | 207,18 | 3276                                  | 3278                                   | 0,999  |
| cos $\phi$ max. over-excited   | 206,40 | 3038                                  | 3380                                   | 0,899  |
| <b>0,95 U<sub>n</sub> at 100% P<sub>E<sub>max</sub></sub></b>  |        |                                       |  |  |
| cos $\phi$ max. under-excited  | 218,51 | 2978                                  | 3299                                   | 0,903  |
| <b>1,0 U<sub>n</sub> at 100% P<sub>E<sub>max</sub></sub></b>   |        |                                       |  |  |
| cos $\phi$ = 1   | 231,55 | 3290                                  | 3293                                   | 0,999  |



|  |        |      |      |       |
|--|--------|------|------|-------|
| cos $\varphi$ max. under-excited   | 230,48 | 3060 | 3399 | 0,900 |
| cos $\varphi$ max. over-excited  | 230,66 | 2988 | 3314 | 0,902 |
| <b>1,05 U<sub>n</sub> at 100% P<sub>Emax</sub></b>   |        |      |      |       |
| cos $\varphi$ max. over-excited  | 241,98 | 3022 | 3401 | 0,889 |
| <b>1,09 U<sub>n</sub> at 100% P<sub>Emax</sub></b>   |        |      |      |       |
| cos $\varphi$ = 1  | 251,16 | 3293 | 3295 | 0,999 |
| cos $\varphi$ max. under-excited   | 250,95 | 2972 | 3299 | 0,901 |
| <b>S<sub>Emax600</sub> and P<sub>Emax 600</sub></b>  |        |      |      |       |
| S <sub>Emax600</sub> = max(S <sub>Emax600 a</sub> , S <sub>Emax600 b</sub> , S <sub>Emax600 c</sub> ) [VA] |        | 3401 |      |       |
| P <sub>Emax 600</sub> = max(P <sub>Emax600 a</sub> , P <sub>Emax600 b</sub> , P <sub>Emax600 c</sub> ) [W] |        | 3293 |      |       |

|                |  |          |
|----------------|--|----------|
| <b>5.4.3</b>   | <b>Measurement of setting accuracy</b> | <b>P</b> |
| <b>5.4.3.3</b> |  |          |

**Test:**

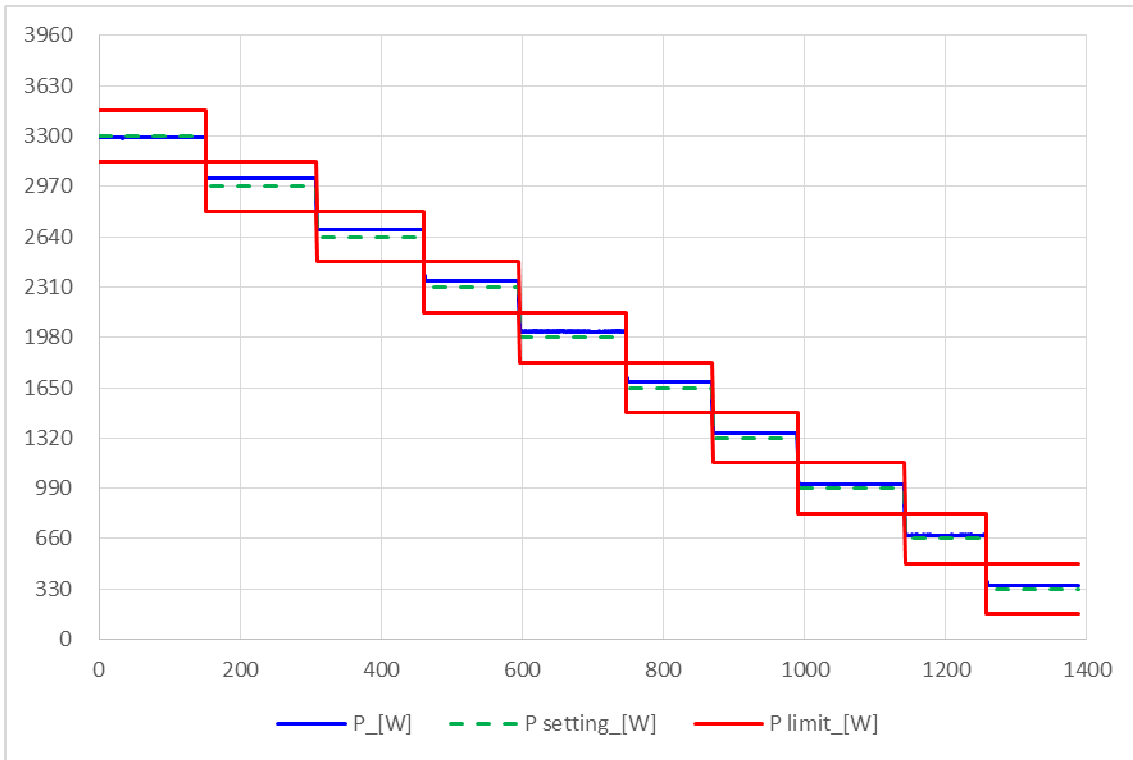
**SOFAR 3300TL-G3**

|   |       |        |        |        |        |        |        |        |        |        |
|---|-------|--------|--------|--------|--------|--------|--------|--------|--------|--------|
| 1-min mean value<br>P/P <sub>rE</sub> [%] | 100   | 90     | 80     | 70     | 60     | 50     | 40     | 30     | 20     | 10     |
| P <sub>Setpoint</sub> [W]                 | 3300  | 2970   | 2640   | 2310   | 1980   | 1650   | 1320   | 990    | 660    | 330    |
| P <sub>E60</sub> [W]                      | 3290  | 3022   | 2687   | 2353   | 2019   | 1684   | 1350   | 1017   | 683    | 352    |
| ΔP <sub>E60</sub> [%]                     | 0.307 | -1.569 | -1.423 | -1.289 | -1.176 | -1.027 | -0.924 | -0.822 | -0.705 | -0.663 |

**Limit**

|                              |                          |   |
|------------------------------|--------------------------|---|
| <b>ΔP<sub>E60</sub> in %</b> | ≤ ±5% of P <sub>rE</sub> | P |
|------------------------------|--------------------------|---|

**Graph of the setting accuracy:**



**Test:**

The setpoint signal must be reduced from 100% to 10% P<sub>rE</sub>:

For adjustable PGUs in increments of 10% P<sub>rE</sub> 1 minute must elapse after every change to the setpoint setting so that the PGU can settle at the new setpoint. Then the active power of the PGU must be measured as a 1-min mean value.

**Assessment criterion:**

a) for adjustable PGUs:

- no network disconnection
- the active power value does not exceed the setpoint by more than ±5% P<sub>rE</sub>
- the setting time determined this way is ≤1min

**Note:**

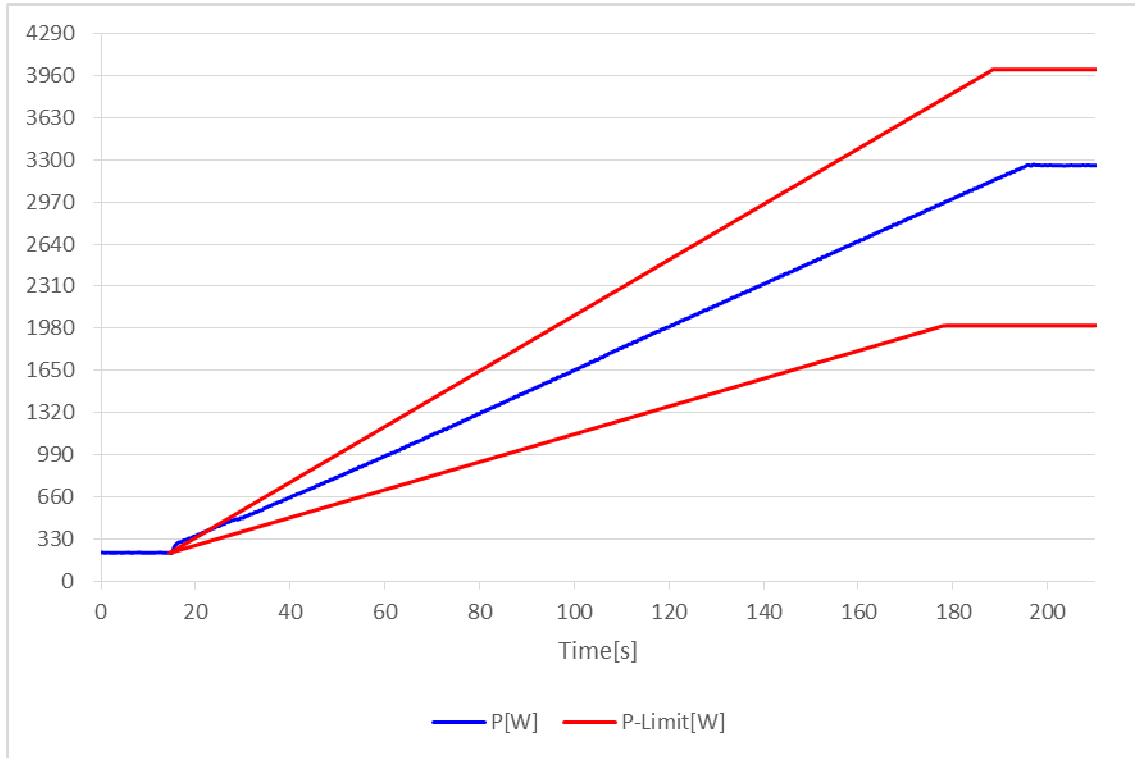
The setting time is ≤ 1min. See below “Graph of the setting accuracy”.

The tests had been performed on the SOFAR 3300TL-G3 is valid for the SOFAR 1100TL-G3, SOFAR 1600TL-G3, SOFAR 2200TL-G3, SOFAR 2700TL-G3 and SOFAR 3000TL-G3 since it is same as in hardware and just power derated by software.

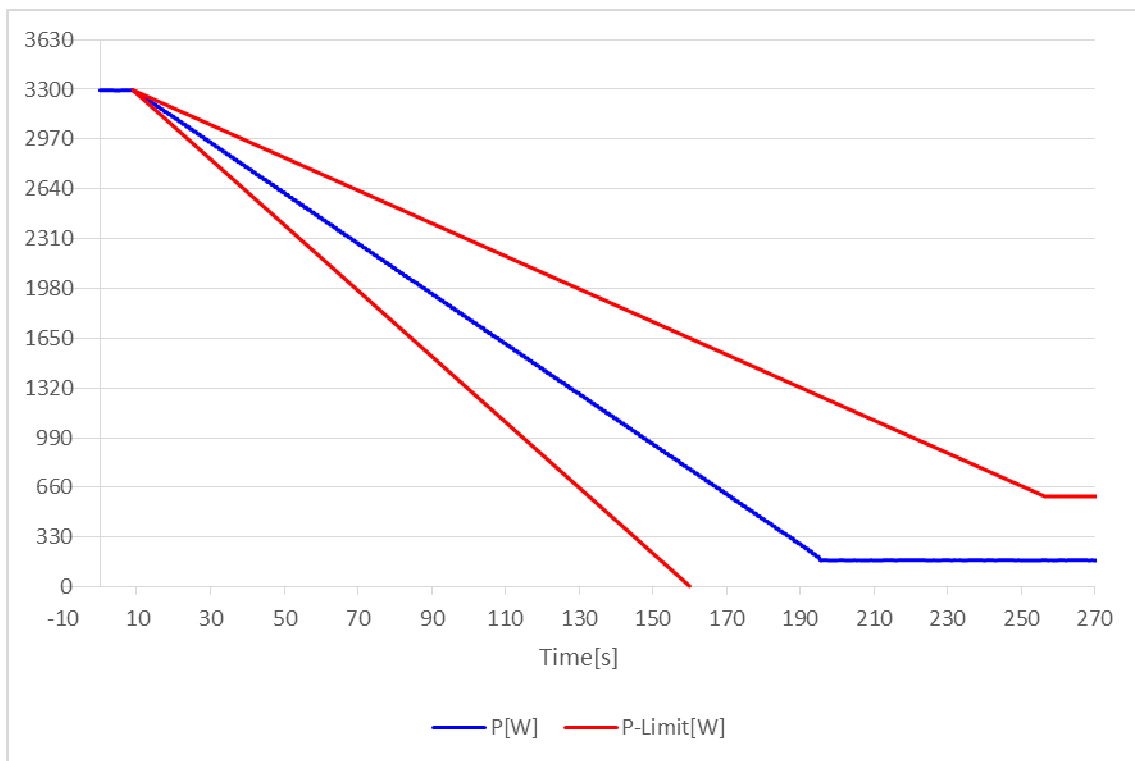
**5.4.3.4 Measurement of the power gradient P**

**SOFAR 3300TL-G3**

**Graph of the gradient <5% to 100% P<sub>TE</sub>**



**Graph of the gradient 100% to <5% P<sub>TE</sub>**





**Test:**

The measurement of the power gradient takes place :

- Via a setpoint change from 100% to 5% of the rated effective power  $P_{rE}$  at time  $t_0$ . If the technical performance is  $>5\%$ , this should be specified.

- Via a setpoint change from 5% to 100% of the rated effective power  $P_{rE}$  at time  $t_0$ . Is the technical Performance  $>5\%$ , this should be specified.

The tests had been performed on the SOFAR 3300TL-G3 is valid for the SOFAR 1100TL-G3, SOFAR 1600TL-G3, SOFAR 2200TL-G3, SOFAR 2700TL-G3 and SOFAR 3000TL-G3 since it is same as in hardware and just power derated by software.

**Assessment criterion:**

for adjustable PGUs:

- no network disconnection
- the active power value does not exceed the setpoint by more than  $5\% P_{rE}$
- the power gradient determined according 5.4.3.4 not be less than  $0,33\% P_{rE}/s$  and not more than  $0,66\% P_{rE}/s$ .

The first gradient is to be created 30 s after the setpoint jump has been set.

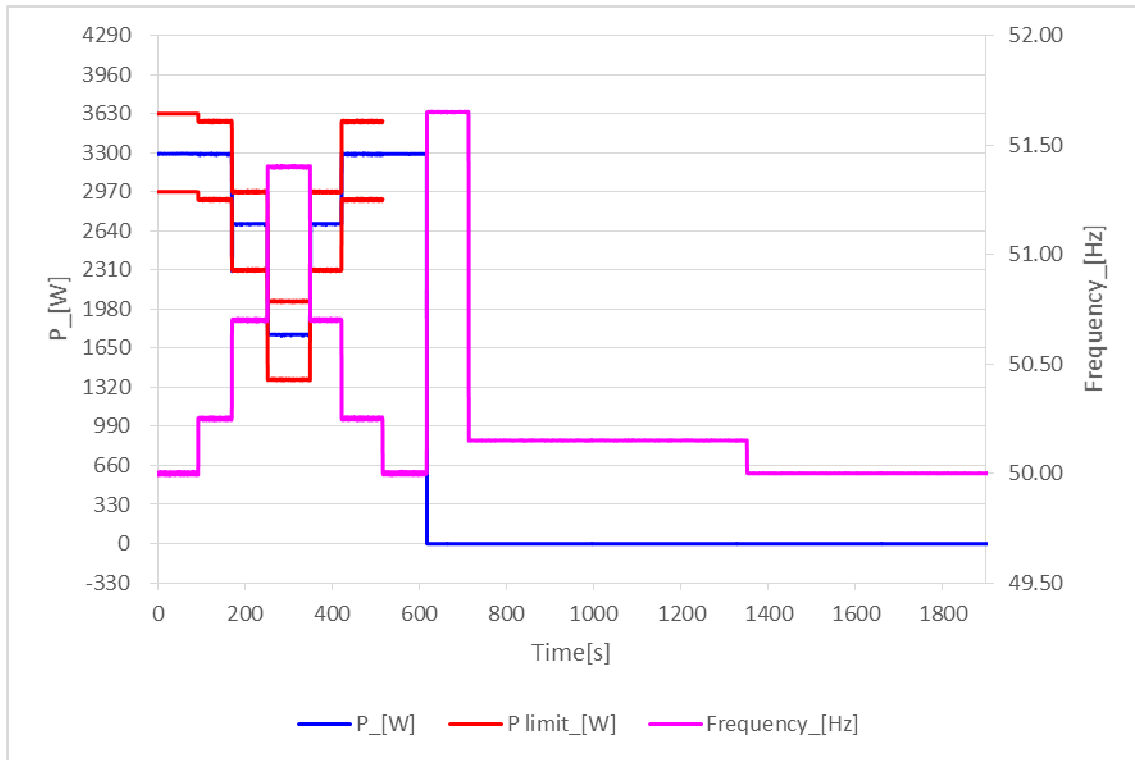
The formation of gradients is ended 30 s before the static end value is reached.

NOTE These times were determined by the maximum or minimum prescribed gradients and with a performance delta of  $\pm 10\% P_{rE}$  around the target value.

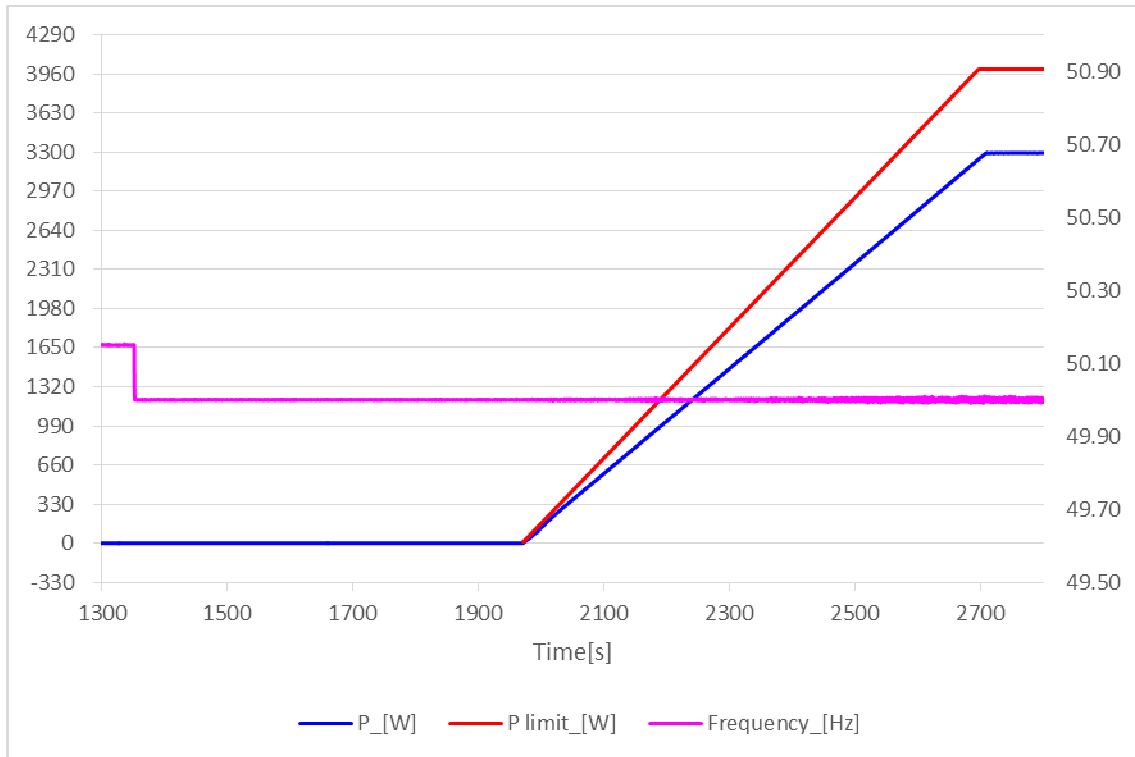


|   |   |       |       |       |       |          |        |       |          |        |          |
|---|---|-------|-------|-------|-------|----------|--------|-------|----------|--------|----------|
| <b>5.4.4</b>  | <b>Active power feed-in for PGU's at overfrequency</b>  |       |       |       |       |          |        |       |          |        | <b>P</b> |
|   | (these tests are designed to provide evidence that the requirements of VDE-AR-N 4105:2018-11 5.7.4.3. and VDE-AR-N 4105:2018-11 8.3.1. are met) |       |       |       |       |          |        |       |          |        |          |
| <b>Test cycle for adjustable PGUs:</b>  |   |       |       |       |       |          |        |       |          |        |          |
| <b>SOFAR 3300TL-G3</b>  |   |       |       |       |       |          |        |       |          |        |          |
| <b>Test 1:</b>  |   |       |       |       |       |          |        |       |          |        |          |
| 1-min mean value:   | 50,00   | 50,25 | 50,70 | 51,40 | 50,70 | 50,25    | 50,00  | 51,65 | 50,15    | 50,00  |          |
| Expected active power output [% of $P_{E_{max}}$ ]  | 100   | 98    | 80    | 52    | 80    | 98       | 100    | 0     | 0        | 100    |          |
| <b>Measurement: 100% <math>P_{E_{max}}</math>; start frequency 50,20Hz; droop s setting = 5% (40% <math>P_{ref}/Hz</math>)</b>    |   |       |       |       |       |          |        |       |          |        |          |
| Frequency [Hz]  | 50,00   | 50,25 | 50,70 | 51,40 | 50,70 | 50,25    | 50,00  | 51,65 | 50,15    | 50,00  |          |
| $P_{setpoint}$ [%]  | 100,00  | 98,00 | 80,00 | 52,00 | 80,00 | 98,00    | 100,00 | 0,00  | 0,00     | 100,00 |          |
| $P_{E60}$ [%]   | 99,74   | 99,71 | 81,82 | 53,49 | 81,83 | 99,70    | 99,70  | 0,00  | 0,00     | 99,74  |          |
| $\Delta P_{E60}$ [%]  | 0,26  | -1,71 | -1,82 | -1,49 | -1,83 | -1,70    | 0,30   | 0,00  | 0,00     | 0,26   |          |
| Available DC-power [%]  | 100   |       |       |       |       |          |        |       |          |        |          |
| <b>Test 2:</b>  |   |       |       |       |       |          |        |       |          |        |          |
| 1-min mean value:   | 50,00   | 50,40 | 50,70 | 51,40 | 50,70 | 50,40    | 50,00  |       |          |        |          |
| Expected active power output [% of $P_{E_{max}}$ ]  | 60  | 60    | 58    | 51    | 58    | 60 - 100 | 100    |       |          |        |          |
| <b>Measurement: 60% <math>P_{E_{max}}</math>; start frequency 50,50Hz; droop s setting = 12% (16,67% <math>P_{ref}/Hz</math>)</b> |   |       |       |       |       |          |        |       |          |        |          |
| Frequency [Hz]  | 50,00   | 50,40 | 50,70 | 51,40 | 50,70 | 50,40    | 50,00  |       |          |        |          |
| $P_{setpoint}$ [%]  | 60,00   | 60,00 | 58,00 | 51,00 | 58,00 | 60,00    | 100,00 |       |          |        |          |
| $P_{E60}$ [%]   | 60,59   | 60,58 | 59,14 | 52,00 | 59,13 | 61,19    | 100,34 |       |          |        |          |
| $\Delta P_{E60}$ [%]  | -0,59   | -0,58 | -1,14 | -1,00 | -1,13 | -1,19    | -0,34  |       |          |        |          |
| Available DC-power [%]  | 60  |       |       | 100   |       |          |        |       |          |        |          |
| <b>Limit</b>  |   |       |       |       |       |          |        |       |          |        |          |
| $\Delta P_{E60}$ in %   | $\leq \pm 10\%$ of $P_{E_{max}}$  |       |       |       |       |          |        |       | <b>P</b> |        |          |
| <b>DC setting values:</b>   |   |       |       |       |       |          |        |       |          |        |          |
| PV-curve simulated according to   | EN 50530  |       |       |       |       |          |        |       |          |        |          |
| Voltage of defined MPP [V]  | 360V d.c.   |       |       |       |       |          |        |       |          |        |          |
| Current of defined MPP [A]  | 10,0A d.c.  |       |       |       |       |          |        |       |          |        |          |
| FFU of PV curve [1]   | 1   |       |       |       |       |          |        |       |          |        |          |
| $P_{DC}$ [W]  | 3497  |       |       |       |       |          |        |       |          |        |          |

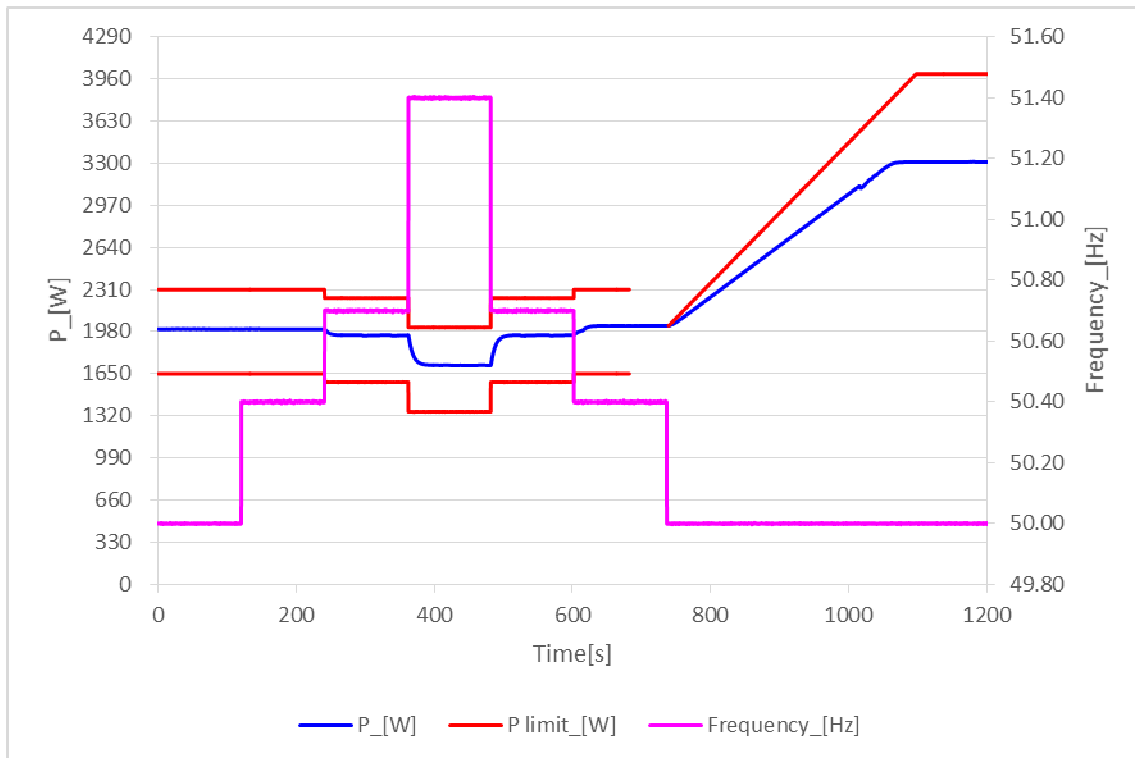
**Graph Test 1@ 100% P<sub>E</sub>max**



**Gradient Test 1@ 100% P<sub>E</sub>max**



Graph Test2 @ 60% P<sub>E</sub>max



**Assessment criterion:**

The test is regarded as passed:

**a) for controllable PGU if:**

- The active power reduces between measuring points 5.4.4.1 a) to g) and j), the expected active power output, after settling, adjusts with a deviation  $\leq \pm 10\% P_{E_{max}}$ .
- In the measurement points h) and i) shall no active power be given.
- The initial time delay  $T_v$  of the frequency-dependent adaptation of the active power output  $\leq 2$  s.
- The response time of the adaptation of the active power output is a maximum of 8 s (type 1 units and type 2 units with rotating machines) or 2 s (all other type 2 units)
- the settling time of the adaptation of the active power output is a maximum time of 30 s (for type 1 units and for type 2 units with rotating machines) or respectively a maximum time of 20 s (for all other generation units type 2) and
- The connection time at point j) is at least 60 s and the power is then increased with a gradient of  $\leq 10\% P_{E_{max}}/\text{min}$ .
- In the case of generating units with combustion engines or gas turbines, if the criteria for response time and settling time are not met, the test shall be passed, even if the adaptation of active power output occurs with a power gradient of at least 66%  $P_{E_{max}}$  per min (corresponding to 1,11%  $P_{E_{max}}$  per s).

**b) for conditionally adjustable PGU, if:**

- they behave as described in a) inside their control range and
- outside the control range, the power supplied when leaving the control range remains constant until it is switched off
- the connection time in j) and where appropriate in g) corresponds to the manufacturer's information on the random number generator;

NOTE: The Uniform distribution of the disconnection frequency in maximum increments of 0,1 Hz between the end of the control range (at least 50,2 Hz) and 51,5 Hz shall be proofed by a manufacturer's declaration.

**c) for non-adjustable PGU, if**

- a disconnection takes place between 50,2 Hz and 51,5 Hz;
- the connection time in j) and where appropriate in g) corresponds to the manufacturer's information on the random number generator;

NOTE The Uniform distribution of the disconnection frequency in maximum increments of 0,1 Hz between 50,2 Hz and 51,5 Hz shall be proofed by a manufacturer's declaration.

**d) for linear generators with  $S_{E_{max}} \leq 4,6$  kVA,**

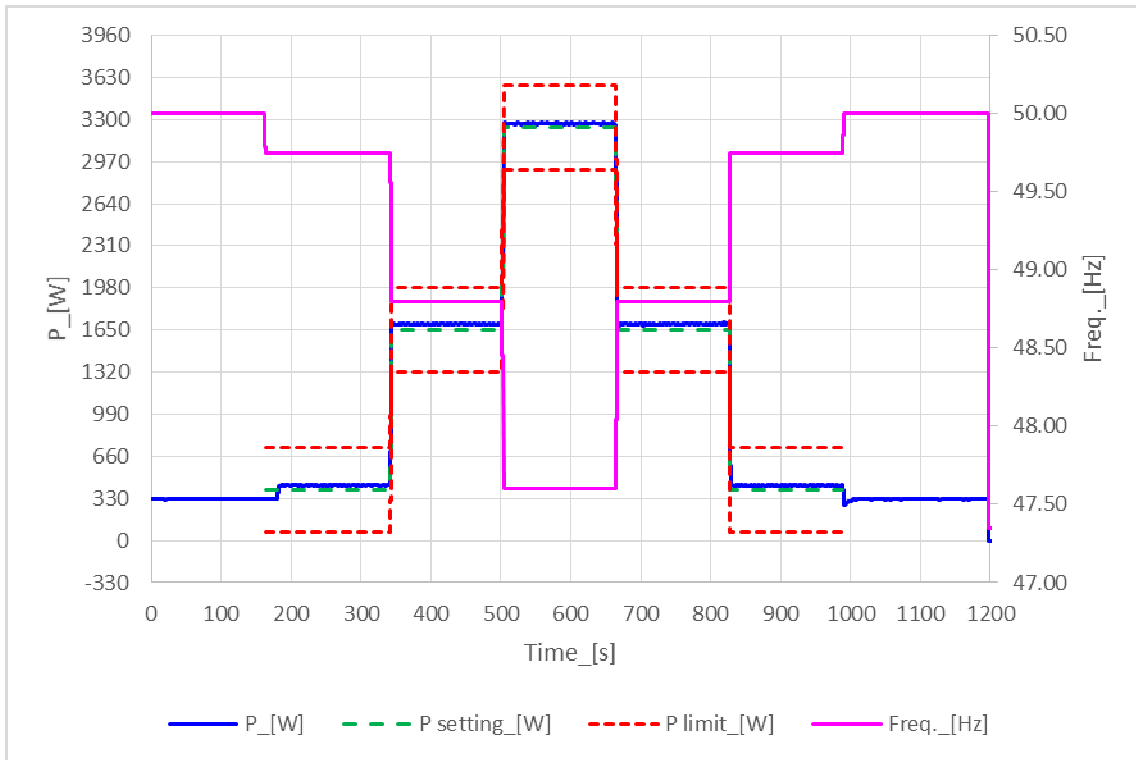
- if they disconnect from the mains at a frequency  $\geq 50,2$  Hz and their maximum upper frequency limit (as specified by the manufacturer), but at the latest when they exceed 51,5 Hz.
- the connection time in j) and where appropriate in g) corresponds to the manufacturer's information on the random number generator;

Subsequently no more resynchronisation/active power feed-in is permitted, also while the frequency 5.4.4.1 i) is maintained (i.e. no running on the characteristic curve as previously tested in a) at g).

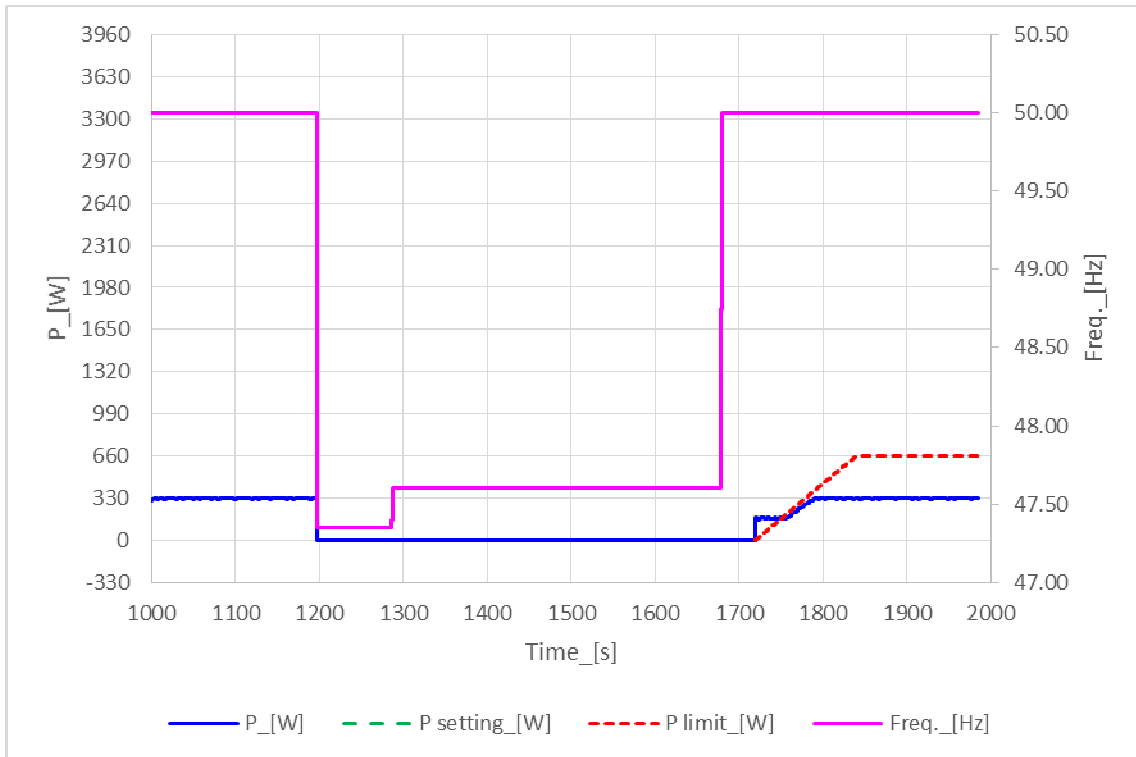
The tests had been performed on the SOFAR 3300TL-G3 is valid for the SOFAR 1100TL-G3, SOFAR 1600TL-G3, SOFAR 2200TL-G3, SOFAR 2700TL-G3 and SOFAR 3000TL-G3 since it is same as in hardware and just power derated by software.

|   |   |       |       |        |       |       |       |       |       |          |
|---|---|-------|-------|--------|-------|-------|-------|-------|-------|----------|
| <b>5.4.6</b>  | <b>Active power feed-in for PGUs at underfrequency</b><br>(these tests are designed to provide evidence that the requirements of VDE-AR-N 4105:2018-11 5.7.4.3. and VDE-AR-N 4105:2018-11 8.3.1. are met)<br>(not for DC-coupled Storage systems) |       |       |        |       |       |       |       |       | <b>P</b> |
| <b>Test cycle for adjustable PGUs:</b>  |   |       |       |        |       |       |       |       |       |          |
| <b>SOFAR 3300TL-G3</b>  |   |       |       |        |       |       |       |       |       |          |
| <b>Test 1:</b>  |   |       |       |        |       |       |       |       |       |          |
| 1-min mean value:   | 50,00   | 49,75 | 48,80 | 47,60  | 48,80 | 49,75 | 50,00 | 47,35 | 47,60 | 50,00    |
| Expected active power output [% of P <sub>E<sub>max</sub></sub> ]:  | 10  | 12    | 50    | 98     | 50    | 12    | 100   | 0     | 0     | 10       |
| <b>Measurement: 10% P<sub>E<sub>max</sub></sub>; start frequency 49,80Hz; droop s setting = 5% (40% P<sub>ref</sub>/Hz)</b> |   |       |       |        |       |       |       |       |       |          |
| Frequency [Hz]:   | 50,00   | 49,75 | 48,80 | 47,60  | 48,80 | 49,75 | 50,00 | 47,35 | 47,60 | 50,00    |
| P <sub>setpoint</sub> [W]:  | 10,00   | 12,00 | 50,00 | 98,00  | 50,00 | 12,00 | 10,00 | 0,00  | 0,00  | 10,00    |
| P <sub>E60</sub> [W]:   | 9,91  | 13,05 | 51,40 | 99,03  | 51,41 | 13,11 | 9,89  | 0,00  | 0,00  | 9,90     |
| ΔP <sub>E60</sub> [%]   | -0,09   | 1,05  | 1,40  | 1,03   | 1,41  | 1,11  | -0,11 | 0,00  | 0,00  | -0,10    |
| Available DC-power [%]:   | 10%P <sub>E<sub>max</sub></sub>   |       |       |        |       |       |       |       |       |          |
| <b>Test 2:</b>  |   |       |       |        |       |       |       |       |       |          |
| 1-min mean value:   | 50,00   | 49,75 | 49,20 | 48,80  | 49,20 | 49,85 | 50,00 |       |       |          |
| Expected active power output [% of P <sub>E<sub>max</sub></sub> ]:  | 60  | 62    | 84    | 100    | 84    | 60    | 60    |       |       |          |
| <b>Measurement: 60% P<sub>E<sub>max</sub></sub>; start frequency 49,80Hz; droop s setting = 5% (40% P<sub>ref</sub>/Hz)</b> |   |       |       |        |       |       |       |       |       |          |
| Frequency [Hz]:   | 50,00   | 49,75 | 49,20 | 48,80  | 49,20 | 49,85 | 50,00 |       |       |          |
| P <sub>setpoint</sub> [W]:  | 60,00   | 62,00 | 84,00 | 100,00 | 84,00 | 60,00 | 60,00 |       |       |          |
| P <sub>E60</sub> [W]:   | 59,68   | 63,46 | 85,57 | 98,97  | 85,62 | 61,57 | 61,48 |       |       |          |
| ΔP <sub>E60</sub> [%]   | 0,32  | -1,46 | -1,57 | 1,03   | -1,62 | -1,57 | -1,48 |       |       |          |
| Available DC-power [%]:   | 60%P <sub>E<sub>max</sub></sub>   |       |       |        |       |       |       |       |       |          |
| <b>Limit:</b>   |   |       |       |        |       |       |       |       |       |          |
| ΔP <sub>E60</sub> in %  | ≤ ±10% of P <sub>E<sub>max</sub></sub>  |       |       |        |       |       |       | P     |       |          |
| <b>DC setting values:</b>   |   |       |       |        |       |       |       |       |       |          |
| PV-curve simulated according to   | EN 50530  |       |       |        |       |       |       |       |       |          |
| Voltage of defined MPP [V]  | 360V d.c.   |       |       |        |       |       |       |       |       |          |
| Current of defined MPP [A]  | 10,0A d.c.  |       |       |        |       |       |       |       |       |          |
| FFU of PV curve [1]   | 1   |       |       |        |       |       |       |       |       |          |
| P <sub>DC</sub> [W]   | 3497  |       |       |        |       |       |       |       |       |          |

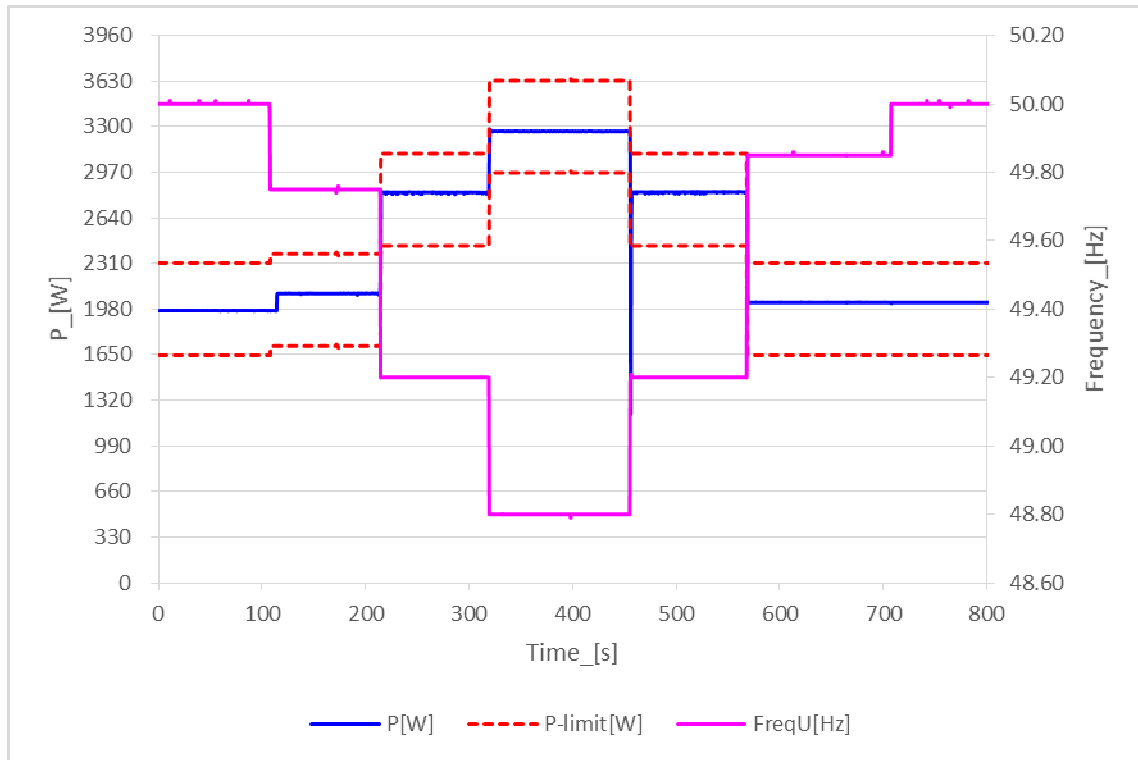
**Graph Test 1@ 10% P<sub>Emax</sub>**



**Gradient Test 1**



**Graph Test2 @ 60% P<sub>Emax</sub>**



**Assessment criterion:**

The test is regarded as passed:

a) for controllable PGU if:

- The active power reduces between measuring points 5.4.4.1 a) to g) and j), the expected active power output, after settling, adjusts with a deviation  $\leq \pm 10\% P_{Emax}$ . Deviations according to VDE-AR-N 4105: 2018-11, 5.7.4.3, Figure 13 and due to the technical restrictions described are permissible. In the measuring points h) and i) no active power may be delivered,
- The initial time delay  $T_V$  of the frequency-dependent adaptation of the active power output  $\leq 2$  s.
- The response time of the adaptation of the active power output is a maximum of 8 s (type 1 units and type 2 units with rotating machines) or 2 s (all other type 2 units)
- the settling time of the adaptation of the active power output is a maximum time of 30 s (for type 1 units and for type 2 units with rotating machines) or respectively a maximum time of 20 s (for all other generation units type 2) and
- The connection time at point j) is at least 60 s and the power is then increased with a gradient of  $\leq 10\% P_{Emax} / \text{min}$ .
- In the case of generating units with combustion engines or gas turbines, if the criteria for response time and settling time are not met, the test shall be passed, even if the adaptation of active power output occurs with a power gradient of at least 66%  $P_{Emax}$  per min (corresponding to 1,11%  $P_{Emax}$  per s).

b) for conditionally adjustable PGU, if:

- they behave as described in a) inside their control range and
- no disconnection takes place between 49,8 Hz and 47,5 Hz;
- the connection time in j) corresponds to the manufacturer's information on the random number generator;

NOTE: The Uniform distribution of the disconnection frequency in maximum increments of 0,1 Hz between the end of the control range (at least 50,2 Hz) and 51,5 Hz shall be proofed by a manufacturer's declaration.

c) for non-adjustable PGU, if

- no disconnection takes place between 49,8 Hz and 47,5 Hz;
- the connection time in j) corresponds to the manufacturer's information on the random number generator;

NOTE The Uniform distribution of the disconnection frequency in maximum increments of 0,1 Hz between 50,2 Hz and 51.5 Hz shall be proofed by a manufacturer's declaration.

d) for linear generators with  $S_{Emax} \leq 4,6$  kVA,

- if they disconnect from the mains at a frequency  $\leq 49,8$  Hz and their maximum upper frequency limit (as specified by the manufacturer), but at the latest when they exceed 47,5 Hz.

the connection time in j) corresponds to the manufacturer's information on the random number generator;

Subsequently no more resynchronization/active power feed-in is permitted, also while the frequency 5.4.4.1 i) is maintained (i.e no running on the characteristic curve as previously tested in a) at g).

**Note:**

The tests had been performed on the SOFAR 3300TL-G3 is valid for the SOFAR 1100TL-G3, SOFAR 1600TL-G3, SOFAR 2200TL-G3, SOFAR 2700TL-G3 and SOFAR 3000TL-G3 since it is same as in hardware and just power derated by software.



|   |  |           |                       |           |                       |           |
|---|--|-----------|-----------------------|-----------|-----------------------|-----------|
| <b>5.4.8</b>                                      | <b>Static voltage stability / reactive power supply</b>  |           |                       |           |                       |           |
|   | The test serves as verification of the reactive power mode according to VD-AR-N 4105: 2018-11, 5.7.2 of the PGU in normal operation. |           |                       |           |                       |           |
| <b>5.4.8.2</b>                                    | <b>Tests of the Reactive power / cos <math>\varphi</math> setting accuracy</b>   |           |                       |           |                       | <b>P</b>  |
| <b>Setting values</b>                             | cos $\varphi$ under-excited  |           |                       | 0,90      | 0,95                  |           |
|   | cos $\varphi$ over-excited   |           |                       | 0,90      | 0,95                  |           |
| <b>Test:</b>                                      |  |           |                       |           |                       |           |
| SOFAR 3300TL-G3                                   |  |           |                       |           |                       |           |
| 60 s mean value                                   | 0,9 $U_n$  |           | $U_n$                 |           | 1,1 $U_n$             |           |
| Active power                                      | 40 – 60%<br>$P_{E60}$  | $S_{E60}$ | 40 – 60%<br>$P_{E60}$ | $S_{E60}$ | 40 – 60%<br>$P_{E60}$ | $S_{E60}$ |
| <b>cos <math>\varphi</math> 0,9 over-excited</b>  |  |           |                       |           |                       |           |
| U [V]   | 207,08   | 207,08    | 229,96                | 230,06    | 253,54                | 252,96    |
| $P_{E60}$ [W]                                     | 1608   | 3045      | 1611                  | 3054      | 1657                  | 3070      |
| $Q_{E60}$ [VAr]                                   | 772  | 1481      | 774                   | 1480      | 791                   | 1469      |
| $S_{E60}$ [VA]                                    | 1784   | 3386      | 1787                  | 3394      | 1836                  | 3403      |
| cos $\varphi_{E60}$ over-excited                  | 0,9015   | 0,8993    | 0,9014                | 0,8999    | 0,9024                | 0,9020    |
| $Q_{expected}$ [VA]                               | 778  | 1476      | 779                   | 1479      | 800                   | 1483      |
| $\Delta Q_{E60}$ [%]                              | -0,17  | 0,14      | -0,16                 | 0,02      | -0,28                 | -0,44     |
| <b>cos <math>\varphi</math> 0,9 under-excited</b> |  |           |                       |           |                       |           |
| U [V]   | 207,03   | 207,11    | 230,03                | 230,10    | 253,56                | 253,00    |
| $P_{E60}$ [W]                                     | 1606   | 2999      | 1609                  | 2987      | 1656                  | 2974      |
| $Q_{E60}$ [VAr]                                   | -793   | -1409     | -797                  | -1428     | -811                  | -1437     |
| $S_{E60}$ [VA]                                    | 1791   | 3314      | 1795                  | 3311      | 1843                  | 3303      |
| cos $\varphi_{E60}$ under-excited                 | 0,8968   | 0,9051    | 0,8960                | 0,9021    | 0,8980                | 0,9004    |
| $Q_{expected}$ [VA]                               | -781   | -1445     | -783                  | -1443     | -804                  | -1440     |
| $\Delta Q_{E60}$ [%]                              | -0,36  | 1,07      | -0,44                 | 0,45      | -0,22                 | 0,09      |
| <b>cos <math>\varphi</math> 0,95 over-excited</b> |  |           |                       |           |                       |           |
| U [V]   | 230,46   | 207,36    | 207,42                | 229,46    | 253,58                | 253,24    |
| $P_{E60}$ [W]                                     | 1666   | 3220      | 1655                  | 3218      | 1664                  | 3227      |
| $Q_{E60}$ [Var]                                   | 539  | 1040      | 524                   | 1054      | 533                   | 1035      |
| $S_{E60}$ [VA]                                    | 1751   | 3384      | 1736                  | 3386      | 1747                  | 3389      |
| cos $\varphi_{E60}$ over-excited                  | 0,9515   | 0,9515    | 0,9533                | 0,9503    | 0,9523                | 0,9522    |
| $Q_{expected}$ [VA]                               | 547  | 1057      | 542                   | 1057      | 546                   | 1058      |
| $\Delta Q_{E60}$ [%]                              | -0,25  | -0,50     | -0,55                 | -0,11     | -0,38                 | -0,72     |

|   |  |               |                           |               |                           |               |
|---|--|---------------|---------------------------|---------------|---------------------------|---------------|
| <b>5.4.8</b>                                    | <b>Static voltage stability / reactive power supply</b>  |               |                           |               |                           |               |
|   | The test serves as verification of the reactive power mode according to VD-AR-N 4105: 2018-11, 5.7.2 of the PGU in normal operation. |               |                           |               |                           |               |
| <b>5.4.8.2</b>                                  | <b>Tests of the Reactive power / cos <math>\phi</math> setting accuracy</b>  |               |                           |               |                           | <b>P</b>      |
| <b>Setting values</b>                           | cos $\phi$ under-excited   |               | 0,90                      |               | 0,95                      |               |
|   | cos $\phi$ over-excited  |               | 0,90                      |               | 0,95                      |               |
| <b>Test:</b>                                    |  |               |                           |               |                           |               |
| SOFAR 3300TL-G3                                 |  |               |                           |               |                           |               |
| 60 s mean value                                 | 0,9 $U_n$  |               | $U_n$                     |               | 1,1 $U_n$                 |               |
| Active power                                    | 40 – 60%<br>$P_{E_{max}}$  | $S_{E_{max}}$ | 40 – 60%<br>$P_{E_{max}}$ | $S_{E_{max}}$ | 40 – 60%<br>$P_{E_{max}}$ | $S_{E_{max}}$ |
| <b>cos <math>\phi</math> 0,95 under-excited</b> |  |               |                           |               |                           |               |
| U [V]   | 230,44   | 207,46        | 208,06                    | 230,21        | 253,93                    | 253,16        |
| $P_{E60}$ [W]                                   | 1664   | 3166          | 1658                      | 3153          | 1664                      | 3141          |
| $Q_{E60}$ [Var]                                 | 566  | 1049          | 564                       | 1049          | 566                       | 1049          |
| $S_{E60}$ [VA]                                  | 1757   | 3335          | 1751                      | 3323          | 1755                      | 3312          |
| cos $\phi_{E60}$ under-excited                  | 0,9467   | 0,9491        | 0,9467                    | 0,9488        | 0,9465                    | 0,9485        |
| $Q_{expected}$ [VA]                             | 549  | 1041          | 547                       | 1038          | 548                       | 1034          |
| $\Delta Q_{E60}$ [%]                            | 0,52   | 0,24          | 0,51                      | 0,35          | 0,55                      | 0,44          |
| <b>Limit</b>                                    |  |               |                           |               |                           |               |
| cos $\phi_{E60}$                                | cos $\phi$ = 0,89 to 0,91 I and cos $\phi$ = 0,89 to 0,91 (i)<br>cos $\phi$ = 0,94 to 0,96 I and cos $\phi$ = 0,94 to 0,96 (i)       |               |                           |               | P                         |               |
| cos $\phi$ settling steps                       | $\leq 0,01$  |               |                           |               | P                         |               |
| $\Delta Q_{E60}$ in %                           | $\leq \pm 4\% P_{E_{max}}$   |               |                           |               | P                         |               |
| <b>Graph: Q/P diagram</b>                       |  |               |                           |               |                           |               |
|   |  |               |                           |               |                           |               |

**Test:**

applies for PGUs Type 2 - only inverter  $\Sigma S_{E_{max}} \leq 4,6$  kVA

a )and b) For  $\cos \varphi$  0,95 over-excited and  $\varphi$  0,95 under-excited, the active power will be measured at value between 40%  $P_{E_{max}}$  and 60% and  $S_{E_{max}}$  and a second time,

for  $\cos \varphi$  0,98 over-excited and  $\varphi$  0,98 under-excited, the active power will be measured at a value between 40%  $P_{E_{max}}$  and 60% and  $S_{E_{max}}$

applies for PGUs Type 2 - only inverter  $\Sigma S_{E_{max}} \geq 4,6$  kVA

c) and d) For  $\cos \varphi$  0,90 over-excited and  $\varphi$  0,90 under-excited, the active power will be measured at value between 40%  $P_{E_{max}}$  and 60% and  $S_{E_{max}}$  and a second time,

for  $\cos \varphi$  0,95 over-excited and  $\varphi$  0,95 under-excited, the active power will be measured at a value between 40%  $P_{E_{max}}$  and 60% and  $S_{E_{max}}$

applies PGUs Type 1 as well as for type 2 plants with Stirling generators and fuel cells  $\Sigma S_{E_{max}} \leq 4,6$  kVA

e) without specification of the  $\cos \varphi$  the active power will be measured at value between 40%  $P_{E_{max}}$  and 60% and  $S_{E_{max}}$ .

applies for PGUs Type 1 as well as for type 2 plants with Stirling generators and fuel cells  $\Sigma S_{E_{max}} > 4,6$  kVA

f) and g) For  $\cos \varphi$  0,95 over-excited and  $\cos \varphi$  0,95 under-excited, the active power will be measured at value between 40%  $P_{E_{max}}$  and 60% and  $S_{E_{max}}$  and a second time,

for  $\cos \varphi$  0,98 over-excited and  $\varphi$  0,98 under-excited, the active power will be measured at a value between 40%  $P_{E_{max}}$  and 60% and  $S_{E_{max}}$

applies for PGUs Type 2 Asynchronous generators:

h) without specification of the  $\cos \varphi$  the active power will be measured at value  $S_{E_{max}}$ . The test is performed only at  $U_n$ .

**Assessment criterion:**

applies for PGUs Type 2 - only inverter  $\Sigma S_{E_{max}} \leq 4,6$  kVA

The Q setpoint is calculated by using the required  $\cos \varphi$  setpoint one time at 0.95 and one time at 0.98 and the measured apparent power of the fundamental. The test is passed if all the Q 60 s mean values of the fundamental component for a) are in the range of Q set point  $\pm 4\%$   $P_{E_{max}}$  overexcited and for b) in the range of Q set point  $\pm 4\%$   $P_{E_{max}}$  under-excited. In addition, a setting of the  $\cos \varphi$  must be possible within a step size of at least 0.01.

applies for PGUs Type 2 - only inverter  $\Sigma S_{E_{max}} \geq 4,6$  kVA

The Q setpoint is calculated by using the required  $\cos \varphi$  setpoint one time at 0.90 and one time at 0.95 and the measured apparent power of the fundamental. The test is passed if all the Q 60 s mean values of the fundamental component for a) are in the range of Q set point  $\pm 4\%$   $P_{E_{max}}$  overexcited and for c) in the range of Q set point  $\pm 4\%$   $P_{E_{max}}$  under-excited. In addition, a setting of the  $\cos \varphi$  must be possible within a step size of at least 0.01.

applies for PGUs Type 1 as well as for type 2 plants with Stirling generators and fuel cells  $\Sigma S_{E_{max}} \leq 4,6$  kVA

The Q setpoint is calculated by using the required  $\cos \varphi$  setpoint one time at 0.95 and one time at 0.98 and the measured apparent power of the fundamental. The test is passed if all the Q 60 s mean values of the fundamental from e) are in the range Q maximal overexcited till Q minimal under-excited.

applies for PGUs Type 1 as well as for type 2 plants with Stirling generators and fuel cells  $\Sigma S_{E_{max}} \geq 4,6$  kVA

The Q setpoint is calculated by using the required  $\cos \varphi$  setpoint one time at 0.95 and one time at 0.98 and the measured apparent power of the fundamental. The test is passed if all the Q 60 s mean values of the fundamental component for a) are in the range of Q set point  $\pm 4\%$   $P_{E_{max}}$  overexcited and for f) in the range of Q set point  $\pm 4\%$   $P_{E_{max}}$  under-excited. In addition, a setting of the  $\cos \varphi$  must be possible within a step size of at least 0.01.

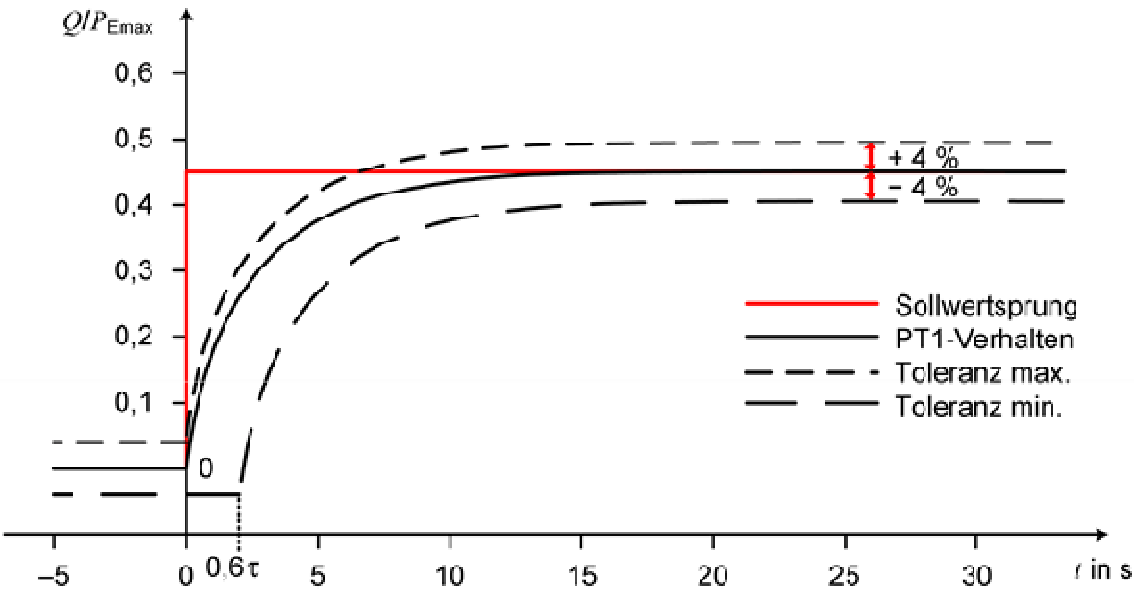
applies for PGUs Type 1 Asynchronous generators:

The test is passed if the  $\cos \varphi$  Q 60 s mean values of h) is in the range  $\cos \varphi = 0,95$  under excited  $\pm 0,02$ .

**Note:**

The tests had been performed on the SOFAR 3300TL-G3 is valid for the SOFAR 1100TL-G3, SOFAR 1600TL-G3, SOFAR 2200TL-G3, SOFAR 2700TL-G3 and SOFAR 3000TL-G3 since it is same as in hardware and just power

derated by software.

|   | The regulating and control behavior of the reactive power | P |
|---|---|---|
| <p>The regulating or control behaviour of the reactive power is based on the PT-1 behaviour shown in Figure 10. Each reactive power value, which results from the control behaviour specified by the network operator, can be set between 6s and 60s (for Type 1 between 10s and 60s). The signal runtime includes the detection of the mains voltage or the active and reactive power.</p> |   |   |
| <div style="text-align: center;"> <p><b>Step response with the tolerances relevant for the evaluation</b></p>  <p><b>Figure 10 - Illustration at 3 tau = 10 s</b></p> </div>   |   |   |
| <p><b>Comment:</b><br/>The regulation and control behaviour according to PT-1 is implemented and checked for all reactive power control modes.</p>  |   |   |

|  |   |       |       |       |       |       |       |          |          |
|--|---|-------|-------|-------|-------|-------|-------|----------|----------|
| <b>5.4.8.3</b>   | <b>Test of the displacement factor/active power characteristic curve <math>\cos \varphi</math> (P)</b>                |       |       |       |       |       |       |          | <b>P</b> |
|  | The test serves as verification of the standard $\cos \varphi$ (P) curve according to VDE-AR-N 4105:2018-11, 5.7.2.4. |       |       |       |       |       |       |          |          |
| <b>SOFAR 3300TL-G3</b>   |   |       |       |       |       |       |       |          |          |
| <b>Test c) supply-dependent PGUs - Accuracy (characteristic curve) (must be used for PV, Wind, Water inverter)</b> |   |       |       |       |       |       |       |          |          |
| <b>Measurement: 20-100% <math>P_{E_{max}}</math></b>   |   |       |       |       |       |       |       |          |          |
| $P_{E_{max}}/P$ [%]  | 20  | 30    | 40    | 50    | 60    | 70    | 80    | 90       | 100      |
| U [V]  | 230,2   | 230,4 | 230,5 | 230,5 | 230,1 | 230,0 | 229,8 | 229,6    | 230,2    |
| $P_{E30}$ [W]  | 650   | 985   | 1317  | 1649  | 1977  | 2303  | 2626  | 2950     | 3016     |
| $P_{E30}$ of $P_{E_{max}}$ [%]   | 19,71   | 29,84 | 39,90 | 49,96 | 59,91 | 69,80 | 79,56 | 89,38    | 91,41    |
| $Q_{E30}$ [Var]  | 33  | 33    | 38    | 46    | -471  | -699  | -966  | -1246    | -1323    |
| $Q_{expected}$   | 0   | 0     | 0     | 0     | -469  | -698  | -962  | -1247    | -1321    |
| $\Delta Q_{E30}$ [%]   | 1,00  | 0,98  | 1,16  | 1,40  | -0,07 | -0,03 | -0,11 | 0,05     | -0,05    |
| $\cos \varphi_{E30}$   | 0,999   | 0,999 | 0,999 | 0,999 | 0,973 | 0,957 | 0,939 | 0,921    | 0,916    |
| $\cos \varphi_{setpoint}$ of $P_{E30}$   | 1,00  | 1,00  | 1,00  | 1,00  | 0,98  | 0,96  | 0,94  | 0,92     | 0,92     |
| $P_{DC}$ [W]   | 676   | 1019  | 1361  | 1703  | 2045  | 2385  | 2721  | 3064     | 3135     |
| <b>Measurement: 100-20% <math>P_{E_{max}}</math></b>   |   |       |       |       |       |       |       |          |          |
| $P_{E_{max}}/P$ [%]  | 100   | 90    | 80    | 70    | 60    | 50    | 40    | 30       | 20       |
| U [V]  | 230,2   | 229,6 | 229,9 | 230,0 | 230,1 | 230,6 | 230,5 | 230,4    | 230,3    |
| $P_{E30}$ [W]  | 3016  | 2949  | 2625  | 2303  | 1975  | 1647  | 1316  | 984      | 651      |
| $P_{E30}$ of $P_{E_{max}}$ [%]   | 91,40   | 89,38 | 79,54 | 69,78 | 59,85 | 49,92 | 39,88 | 29,82    | 19,73    |
| $Q_{E30}$ [Var]  | -1323   | -1246 | -966  | -700  | -471  | 46    | 38    | 32       | 32       |
| $Q_{expected}$   | -1321   | -1247 | -962  | -698  | -469  | 0     | 0     | 0        | 0        |
| $\Delta Q_{E30}$ [%]   | -0,06   | 0,04  | -0,11 | -0,06 | -0,07 | 1,38  | 1,15  | 0,97     | 0,98     |
| $\cos \varphi_{E30}$   | 0,916   | 0,921 | 0,939 | 0,957 | 0,973 | 0,999 | 0,999 | 0,999    | 0,999    |
| $\cos \varphi_{setpoint}$ of $P_{E30}$   | 0,92  | 0,92  | 0,94  | 0,96  | 0,98  | 1,00  | 1,00  | 1,00     | 1,00     |
| $P_{DC}$ [W]   | 3135  | 3066  | 2723  | 2386  | 2044  | 1703  | 1361  | 1019     | 677      |
| <b>Limit</b>   |   |       |       |       |       |       |       |          |          |
| $\Delta Q_{E30}$ in %  | $\leq \pm 4,0\%$ relative to $P_{E_{max}}$  |       |       |       |       |       |       | <b>P</b> |          |

|                |   |          |
|----------------|---|----------|
| <b>5.4.8.3</b> | <b>Test of the displacement factor/active power characteristic curve <math>\cos \phi</math> (P)</b><br>The test serves as verification of the standard $\cos \phi$ (P) curve according to VDE-AR-N 4105:2018-11, 5.7.2.4. | <b>P</b> |
|----------------|---|----------|

**SOFAR 3300TL-G3**

**Test d): supply-dependent PGUs - Dynamic**

|                                     |       |       |       |       |
|-------------------------------------|-------|-------|-------|-------|
| $P_{E_{max}}/P_n$ [%]               | 100   | 40    | 100   | 75    |
| U [V]                               | 230,2 | 230,4 | 230,2 | 230,3 |
| $P_{E30}$ [W]                       | 3018  | 1314  | 3019  | 2463  |
| $P_{E30}$ of $P_{E_{max}}$ [%]      | 91,46 | 39,82 | 91,48 | 74,62 |
| $Q_{E30}$ [VAr]                     | -1323 | 31    | -1322 | -840  |
| $Q_{expected}$                      | -1322 | -19   | -1322 | -841  |
| $\Delta Q_{E30}$ [%]                | -0,03 | 1,51  | 0,00  | 0,02  |
| $\cos \phi_{E30}$                   | 0,916 | 0,999 | 0,916 | 0,946 |
| $\cos \phi_{setpoint}$ of $P_{E30}$ | 0,92  | 1     | 0,92  | 0,95  |
| $T_0$ [s]                           | 0     | 5,2   | 5,8   | 5,2   |

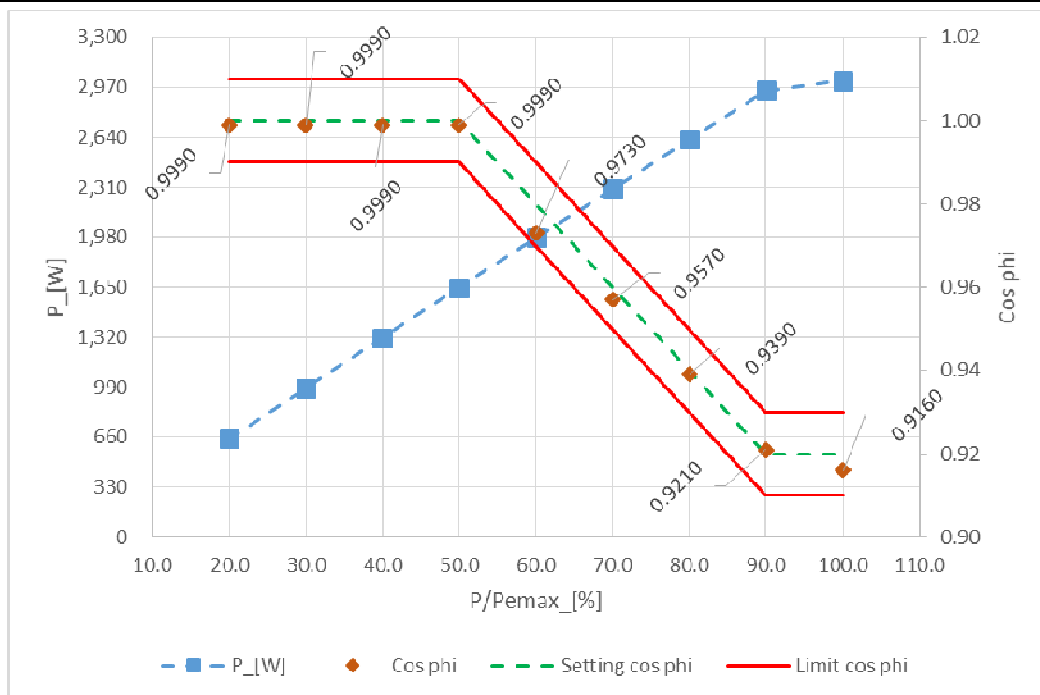
**Limit**

|                       |  |
|-----------------------|--|
| $\Delta Q_{E30}$ in % | $\leq \pm 4,0\%$ relative to $P_{E_{max}}$ |
|-----------------------|--|

**DC setting values:**

|                                 |            |
|---------------------------------|------------|
| PV-curve simulated according to | EN 50530   |
| Voltage of defined MPP [V]      | 360V d.c.  |
| Current of defined MPP [A]      | 10,0A d.c. |
| FFU of PV curve [1]             | 1          |
| $P_{DC}$ [W]                    | 3497       |

**Graph of Test c)**

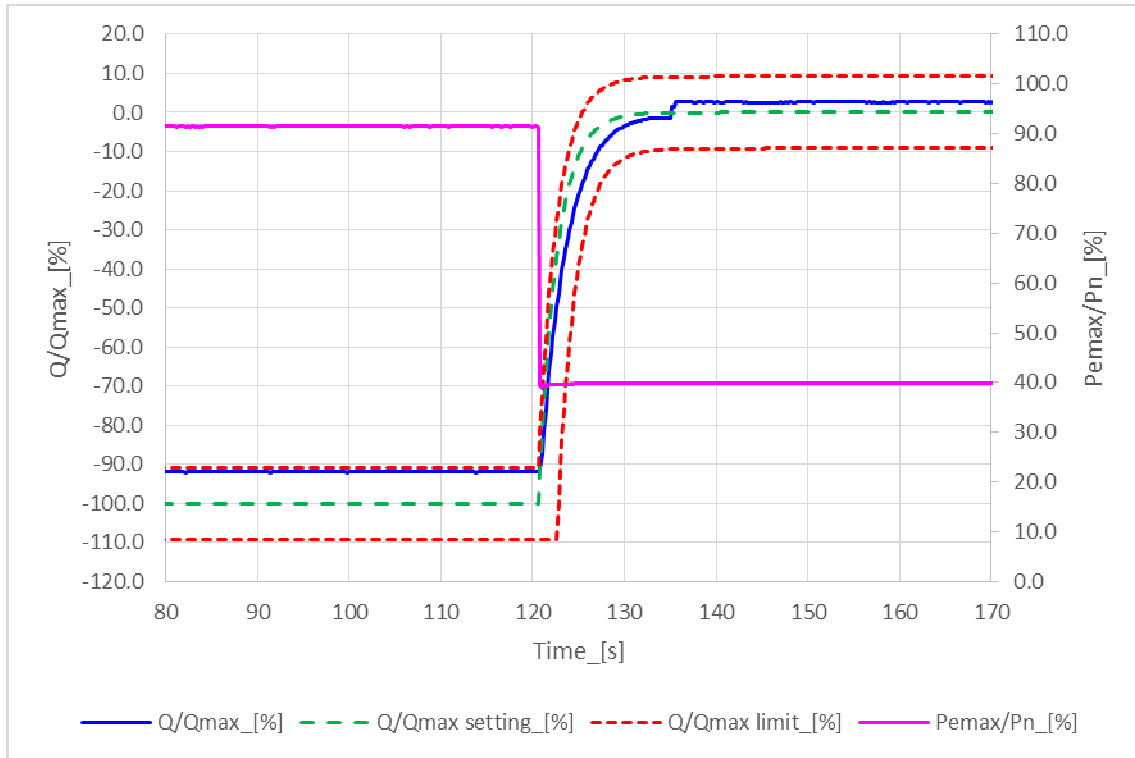


|                       |   |                 |
|-----------------------|---|-----------------|
| <p><b>5.4.8.3</b></p> | <p><b>Test of the displacement factor/active power characteristic curve <math>\cos \phi</math> (P)</b></p> <p>The test serves as verification of the standard <math>\cos \phi</math> (P) curve according to VDE-AR-N 4105:2018-11, 5.7.2.4.</p> | <p><b>P</b></p> |
|-----------------------|---|-----------------|

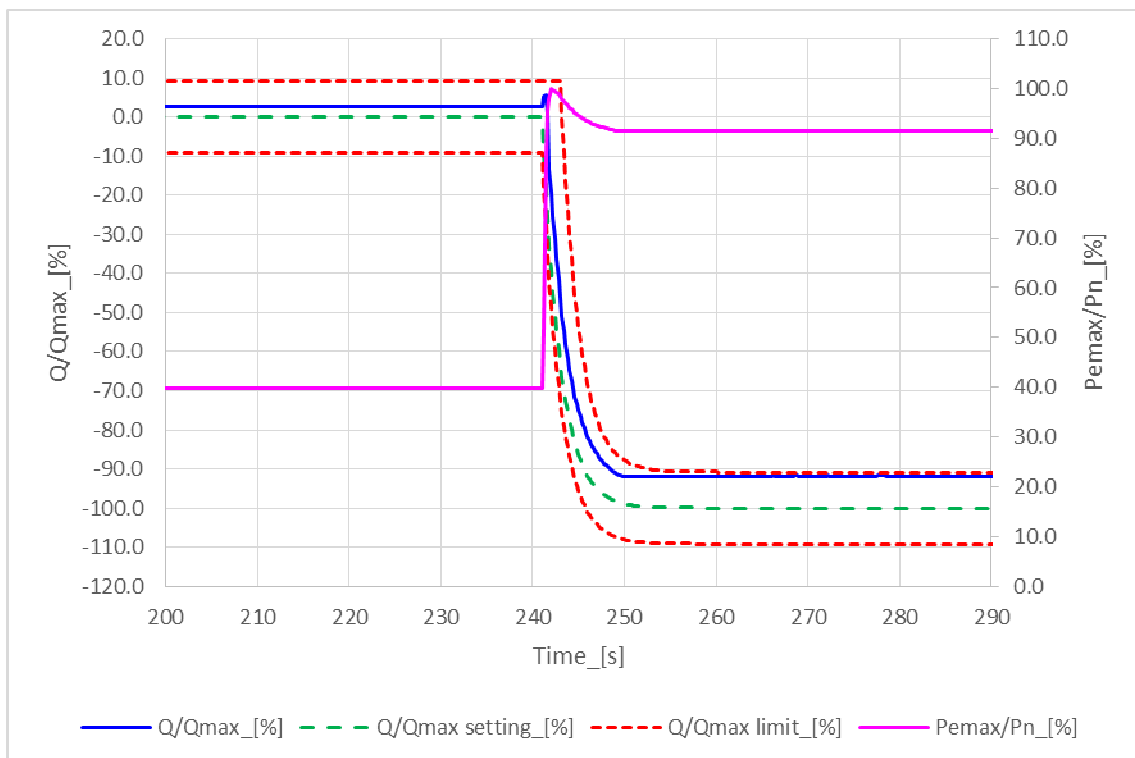
**SOFAR 3300TL-G3**

**Graph of Test d)**

**100%Pn to 40%Pn**



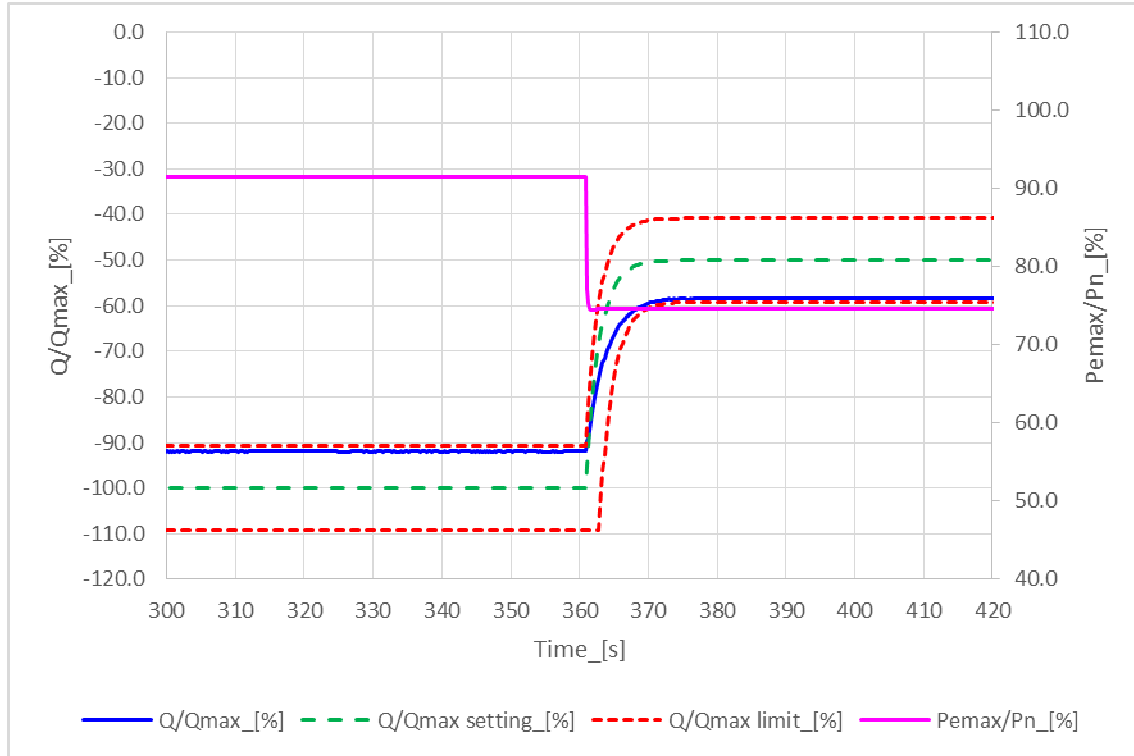
**40%Pn to 100%Pn**



|                |   |          |
|----------------|---|----------|
| <b>5.4.8.3</b> | <b>Test of the displacement factor/active power characteristic curve <math>\cos \phi</math> (P)</b><br>The test serves as verification of the standard $\cos \phi$ (P) curve according to VDE-AR-N 4105:2018-11, 5.7.2.4. | <b>P</b> |
|----------------|---|----------|

**SOFAR 3300TL-G3**

**100%Pn to 75%Pn**



**Assessment criterion:**

Test 5.4.8.3 (2) is considered to have been passed if the PGU meets the requirements for the performance gradient in VDE AR-N 4105: 2018-11, 5.7.4.2.

Test 5.4.8.3 (4) is passed if the step response of the reactive power in test steps c) and e) shows PT1 behavior according to VDE-AR-N 4105: 2018-11, 5.7.2.5 and for test step d) optionally the power gradient lies between the limits defined in VDE AR-N 4105: 2018-11, 5.7.4.1 or the step response of the reactive power also has PT1 behavior according to VDE-AR-N 4105: 2018-11, 5.7.2.5.

The tests had been performed on the SOFAR 3300TL-G3 is valid for the SOFAR 1100TL-G3, SOFAR 1600TL-G3, SOFAR 2200TL-G3, SOFAR 2700TL-G3 and SOFAR 3000TL-G3 since it is same as in hardware and just power derated by software.

**Note:**

The tests had been performed on the SOFAR 3300TL-G3 is valid for the SOFAR 1100TL-G3, SOFAR 1600TL-G3, SOFAR 2200TL-G3, SOFAR 2700TL-G3 and SOFAR 3000TL-G3 since it is same as in hardware and just power derated by software.



| <b>5.4.8.4 Test the reactive power-voltage characteristic Q(U)</b>  |                        |                   |                |                     |                     |
|---|------------------------|-------------------|----------------|---------------------|---------------------|
| The validation of the Q (U) regulation according to VDE-AR-N 4105: 2018-05, 5.7.2.4 is divided into two partial tests, so that on the one hand the accuracy and on the other hand the dynamics of the Q (U) control is checked. For all inverter-coupled systems, only the inverter must be tested. |                        |                   |                |                     |                     |
| <b>5.4.8.4.1 Test of the reactive power-voltage characteristic Q(U)</b>   |                        |                   |                |                     | <b>P</b>            |
| SOFAR 3300TL-G3   |                        |                   |                |                     |                     |
| Vac [% U <sub>n</sub> ]<br>Set point  | Vac_L1 [V]<br>measured | P [W]<br>measured | PF<br>measured | Q [Var]<br>measured | Q [Var]<br>expected |
| 100   | 230,2                  | 3314,1            | 0,999          | 97,2                | 148                 |
| 99  | 227,9                  | 3313,3            | 0,999          | 96,5                | 148                 |
| 98  | 225,6                  | 3312,0            | 0,999          | 97,3                | 148                 |
| 97  | 223,2                  | 3311,1            | 0,999          | 116,6               | 148                 |
| 96  | 220,7                  | 3309,0            | 0,996          | 303,3               | 295                 |
| 95  | 218,3                  | 3280,6            | 0,977          | 713,8               | 704                 |
| 94  | 216,3                  | 3189,6            | 0,947          | 1083,7              | 1060                |
| 93  | 214,0                  | 3072,4            | 0,909          | 1411,8              | 1375                |
| 92  | 211,7                  | 3072,7            | 0,909          | 1412,4              | 1375                |
| 91  | 209,3                  | 3072,9            | 0,909          | 1412,7              | 1375                |
| 90  | 207,1                  | 3072,5            | 0,908          | 1413,7              | 1383                |
| 91  | 209,3                  | 3074,8            | 0,908          | 1413,9              | 1383                |
| 92  | 211,7                  | 3074,1            | 0,909          | 1412,8              | 1375                |
| 93  | 213,9                  | 3074,4            | 0,909          | 1412,4              | 1375                |
| 94  | 216,3                  | 3185,9            | 0,945          | 1105,5              | 1079                |
| 95  | 218,3                  | 3282,2            | 0,976          | 735,4               | 719                 |
| 96  | 220,7                  | 3308,0            | 0,995          | 319,1               | 330                 |
| 97  | 223,2                  | 3309,6            | 0,999          | 146,5               | 148                 |
| 98  | 225,6                  | 3310,7            | 0,999          | 96,1                | 148                 |
| 99  | 227,8                  | 3311,7            | 0,999          | 95,9                | 148                 |
| 100   | 230,2                  | 3312,6            | 0,999          | 96,6                | 148                 |
| 101   | 232,3                  | 3313,7            | 0,999          | 95,7                | 148                 |
| 102   | 234,6                  | 3315,0            | 0,999          | 95,6                | 148                 |
| 103   | 236,9                  | 3315,9            | 0,999          | 95,5                | 148                 |
| 104   | 239,1                  | 3316,6            | 0,998          | -216,1              | -209                |
| 105   | 241,4                  | 3269,1            | 0,984          | -588,2              | -588                |
| 106   | 243,8                  | 3171,4            | 0,956          | -971,2              | -968                |
| 107   | 246,1                  | 3017,9            | 0,913          | -1346,7             | -1346               |
| 108   | 248,3                  | 2987,3            | 0,905          | -1407,3             | -1404               |
| 109   | 250,6                  | 2986,5            | 0,904          | -1408,4             | -1411               |
| 110   | 252,9                  | 2985,0            | 0,904          | -1409,2             | -1411               |
| 109   | 250,5                  | 2987,2            | 0,904          | -1408,7             | -1411               |
| 108   | 248,3                  | 2988,1            | 0,904          | -1408,0             | -1411               |
| 107   | 246,1                  | 3022,1            | 0,914          | -1343,2             | -1339               |
| 106   | 243,8                  | 3148,7            | 0,952          | -1008,5             | -1010               |

**5.4.8.4 Test the reactive power-voltage characteristic Q(U)**  
 The validation of the Q (U) regulation according to VDE-AR-N 4105: 2018-05, 5.7.2.4 is divided into two partial tests, so that on the one hand the accuracy and on the other hand the dynamics of the Q (U) control is checked. For all inverter-coupled systems, only the inverter must be tested.

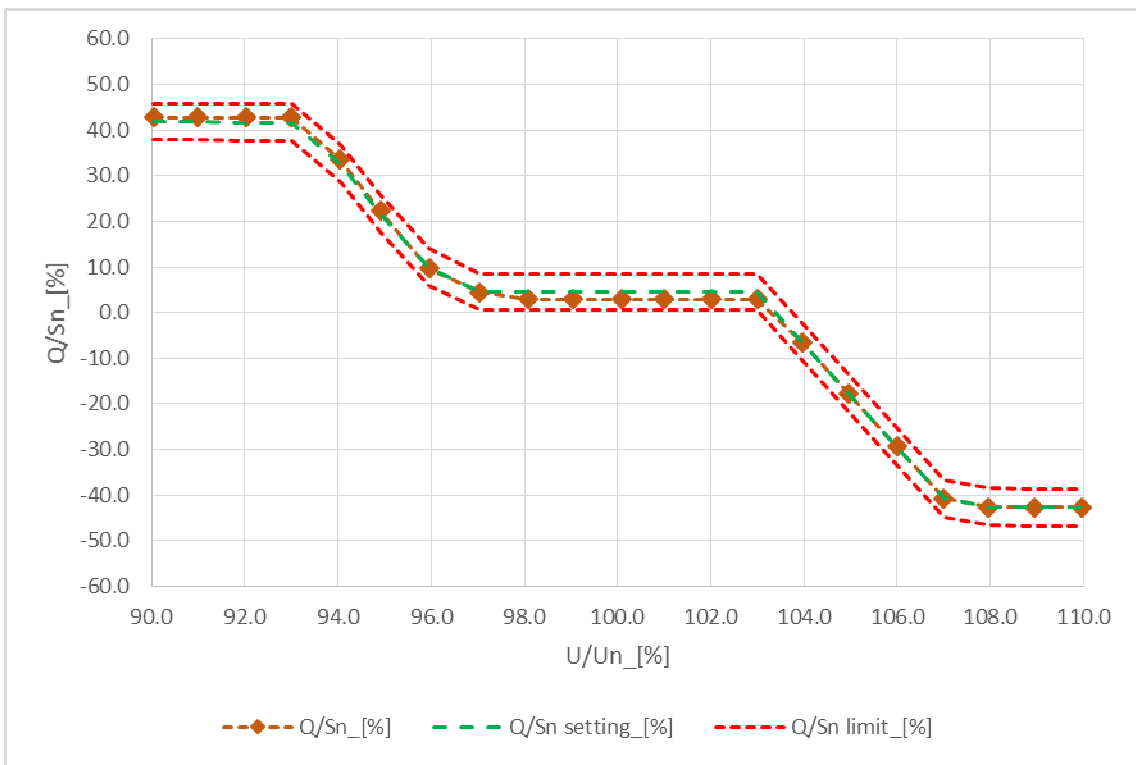
| 5.4.8.4.1       | Test of the reactive power-voltage characteristic Q(U) |        |       |        |      | P |
|-----------------|--|--------|-------|--------|------|---|
| SOFAR 3300TL-G3 |  |        |       |        |      |   |
| 105             | 241,4  | 3266,8 | 0,983 | -603,1 | -606 |   |
| 104             | 239,1  | 3329,6 | 0,998 | -219,8 | -209 |   |
| 103             | 236,9  | 3343,3 | 0,999 | 84,2   | 148  |   |
| 102             | 234,5  | 3342,8 | 0,999 | 86,7   | 148  |   |
| 101             | 232,2  | 3342,1 | 0,999 | 92,7   | 148  |   |
| 100             | 230,2  | 3329,7 | 0,999 | 98,9   | 148  |   |

**Assessment criterion:**  
 In order to pass the Q (U) accuracy test, the measured stationary value pairs  $U_{PGU}$  and  $Q_{PGU}$ , under taking account to the correct sign in the consumer metering system, must be within VDE-AR-N 4105: 2018-11, in 5.7.2.4, Figure 7 Q (U) shown characteristic. The stationary value pairs  $U_{PGU}$  and  $Q_{PGU}$  are determined by averaging over 30 seconds at the end of the respective measuring section analogously to Chapter 5.4.3.2. The permissible deviations are with the maximum measuring error of the voltage of 1%  $U_n$  stated in VDE-AR-N 4105: 2018-11 and a setting accuracy of 4%  $P_{EMax}$ .

$$Q_{EZE,tot} = \pm(0.01 \cdot U_{N,Y} \cdot k_{QU} + 0.04 \cdot P_{EMax}) = \pm 0,25 \cdot P_{EMax} \cdot (\sin(\arccos(\varphi_{min})) + 0.16).$$

**Note:**  
 The tests had been performed on the SOFAR 3300TL-G3 is valid for the SOFAR 1100TL-G3, SOFAR 1600TL-G3, SOFAR 2200TL-G3, SOFAR 2700TL-G3 and SOFAR 3000TL-G3 since it is same as in hardware and just power derated by software.

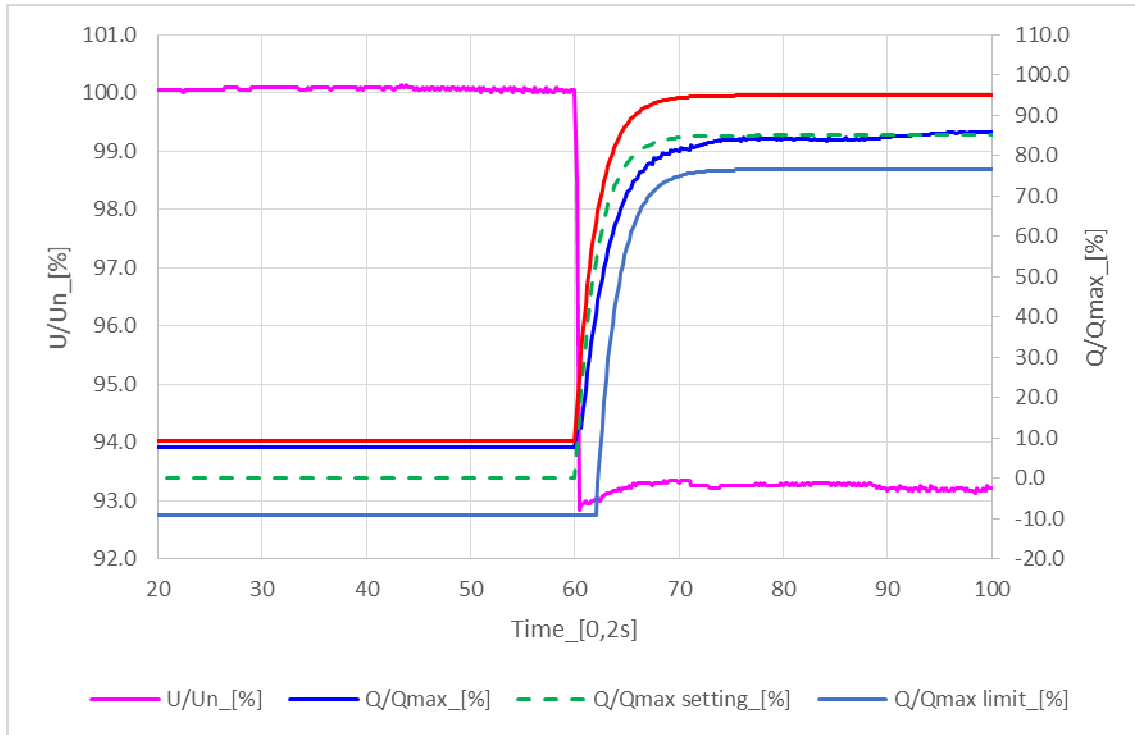
**Graph of Q(U) curve**



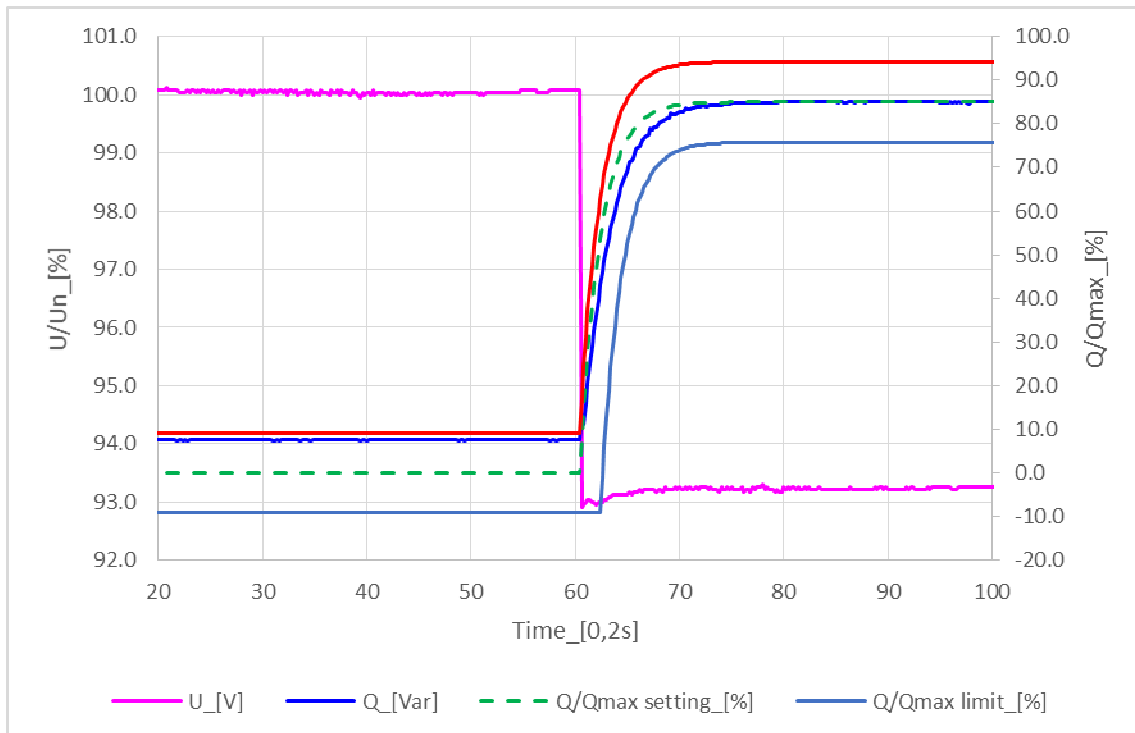
| 5.4.8.4.2                       |                   | Test of the dynamics of the Q(U) regulation                                       |              | P |
|---------------------------------|-------------------|---|--------------|---|
| <b>SOFAR 3300TL-G3</b>          |                   |   |              |   |
| Voltage jump Vac [% Un]         | Q [kVar] measured | Q [%Qmax] measured  | T=3τmeasured |   |
| 100 to 106,4                    | -1186             | -82,4   | 9,8          |   |
|                                 | -1183             | -82,2   | 9,4          |   |
|                                 | -1199             | -83,3   | 9,4          |   |
| 100 to 93,6                     | 1233              | 85,7  | 9,2          |   |
|                                 | 1227              | 85,3  | 8,2          |   |
|                                 | 1223              | 85,0  | 9,4          |   |
| PV-curve simulated according to |                   | EN 50530  |              |   |
| Voltage of defined MPP [V]      |                   | 360V d.c.   |              |   |
| Current of defined MPP [A]      |                   | 10,0A d.c.  |              |   |
| FFU of PV curve [1]             |                   | 1   |              |   |
| Impedance [Ω]                   |                   | Line $R_A = 0,15 \text{ j}X_A = 0,15$<br>Neutral $R_N = 0,01 \text{ j}X_N = 0,01$ |              |   |

**Graph of Q(U) dynamics**

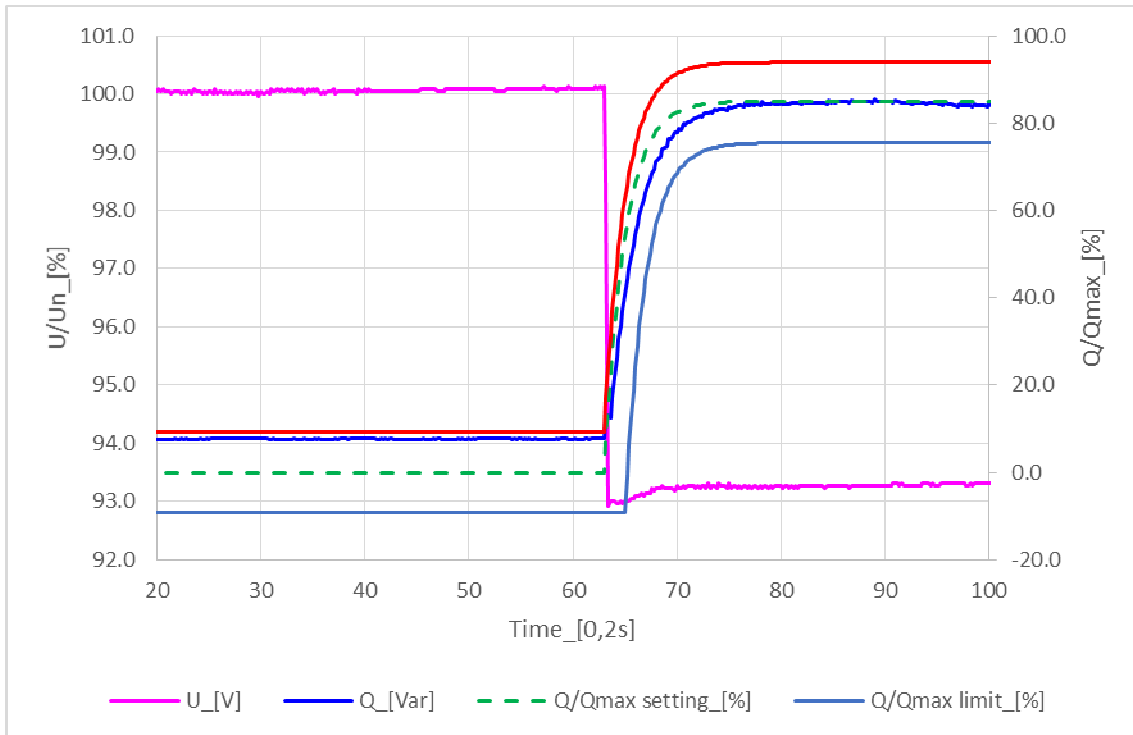
**Test 1 for 0,936Un: SOFAR 3300TL-G3**



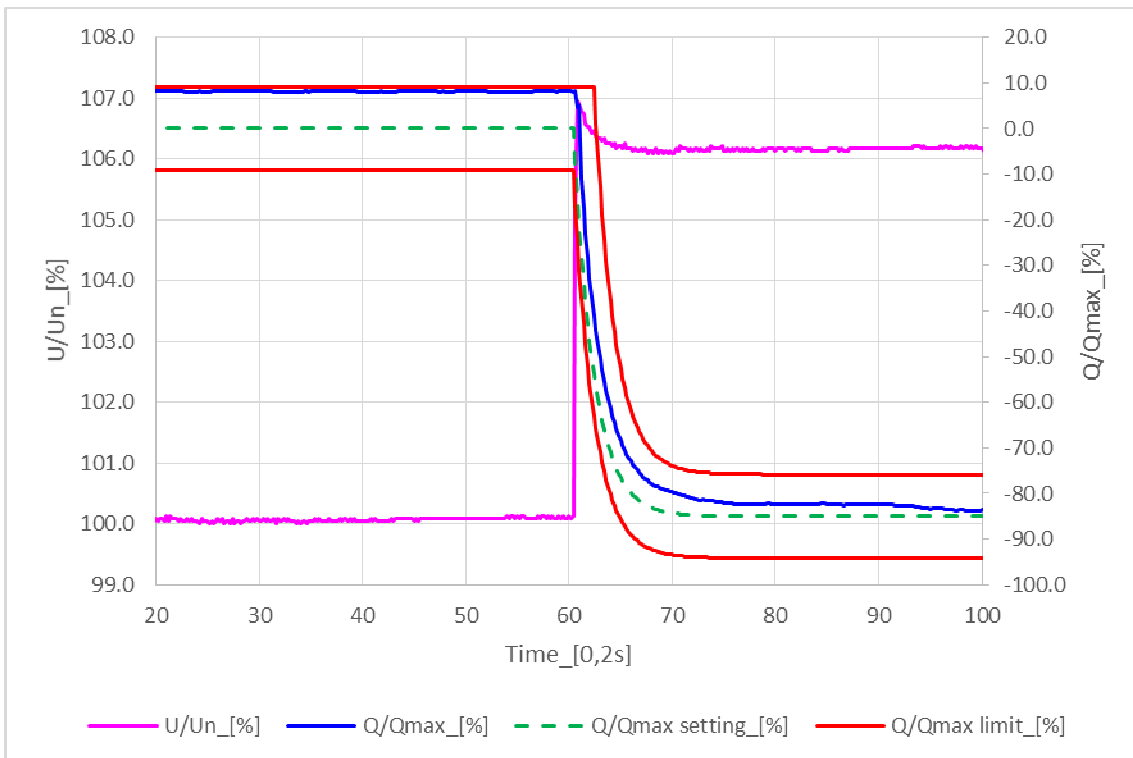
**Test 2 for 0,936Un: SOFAR 3300TL-G3**



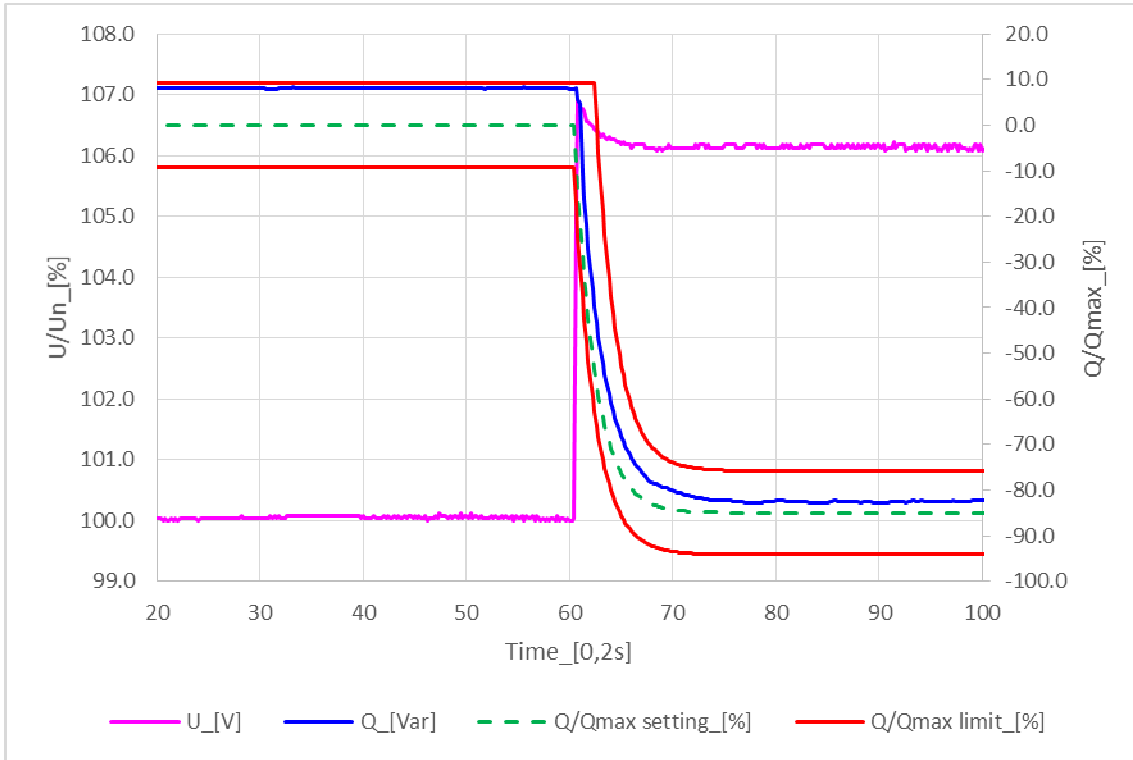
**Test 3 for 0,936Un: SOFAR 3300TL-G3**



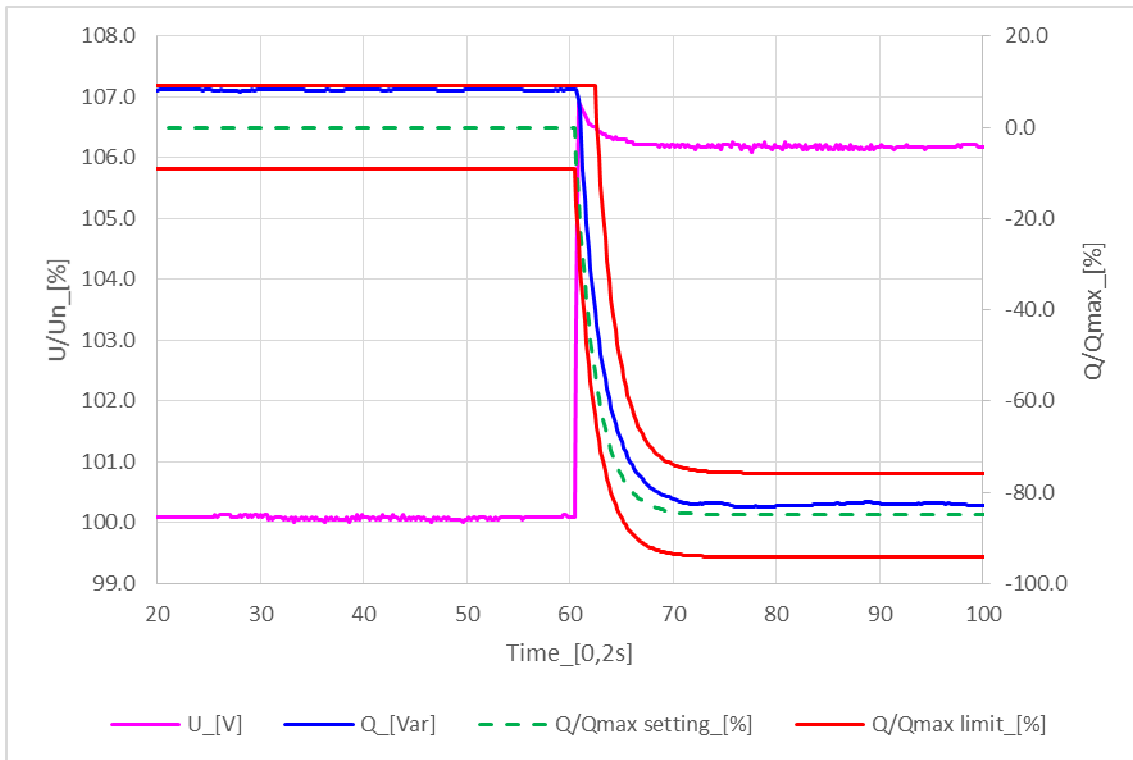
**Test 1 for 1,064Un: SOFAR 3300TL-G3**



**Test 2 for 1,064Un: SOFAR 3300TL-G3**



**Test 3 for 1,064Un: SOFAR 3300TL-G3**



**Assessment criterion:**

For passing the test on the dynamics of the Q (U) control, the measured, time profiles of the reactive power have to be determined in the “positive sequence”  $Q_{PGU}$  during the entire measuring period in the PT1-like tolerances according to VDE-AR-N 4105: 2018-11, 5.7.2.5. For this purpose, the tolerance bands are entered into the diagram of the respective measurement according to the formulas below. It should be distinguished according to the expected PGU behavior (inductive, capacitive). An exemplary representation of the tolerance bands for the capacitive case is shown in Figure 6. Physically caused compensation processes (for example with type 1 PGU) are to be excluded from the evaluation, if they decay in a time range smaller than one third of the Q (U) - set time.

The variable T corresponds to the set - up time of the generating plant and three times the parameterized PT1 time constant Tau ( $T = 3\text{Tau}$ ). The measurement of the time starts at the time of the excitation in 5. 4.8.3.2a) or the manipulation in 5.4.8.3.2 b).

Since the increase or decrease of the voltage according to the formula given in 5.4.8.3.2 represents only an approximation to the real behavior of the closed control loop, the steady-state final value  $Q_{set}$  is determined from the measurement. For this purpose, a 10 - second mean value is formed at the end of the one - minute measurement period via the three - phase reactive power in the positive sequence system. Likewise, the starting value of the reactive power (positive sequence)  $Q_{start}$  (= offset) before the respective voltage change is determined over a 10-second averaging.

The response time of the overall system to be evaluated is measured starting from the excitation according to 5.4.8.3.2 a) or the manipulation according to 5.4.8.3.2 b) until reaching 95% of the steady end value in the positive sequence  $Q_{soll}$  and is with the factor 5/3 to multiply. This factor takes into account the effect of the feedback on the control dynamics of the Q (U) control and is strongly related to the formula of the net replacement reactance.

**Note:**

The tests had been performed on the SOFAR 3300TL-G3 is valid for the SOFAR 1100TL-G3, SOFAR 1600TL-G3, SOFAR 2200TL-G3, SOFAR 2700TL-G3 and SOFAR 3000TL-G3 since it is same as in hardware and just power derated by software.

| <b>5.5 Testing of NS protection</b> |  |                |
|-------------------------------------|--|----------------|
| <b>Clause</b>                       | <b>Requirement – Test</b>  | <b>Verdict</b> |
| 5.5.2                               | NS protection  | P              |
| 5.5.2.1                             | Functional safety  | P              |
| 5.5.3                               | Central NS-protection  | N/A            |
| 5.5.4                               | Integrated NS-protection   | P              |
| 5.5.6                               | Interface switch   | P              |
| 5.5.6.2                             | Central interface switch   | N/A            |
| 5.5.6.3                             | Integrated interface switch  | P              |
| 5.5.7.2                             | Check of setting values  | P              |
| 5.5.7.3                             | Wiring check   | N/A            |
| 5.5.7.4                             | Voltage and frequency control  | P              |
| 5.5.7.4.1                           | Voltage and frequency control – Single Phase   | P              |
|                                     | Voltage and frequency control – Multi Phase (Phase to N)   | N/A            |
|                                     | Voltage and frequency control – Multi Phase (Phase to Phase)   | N/A            |
|                                     | Voltage and frequency control – Measuring the rise-in voltage protection as a running 10-minute mean value             | P              |
|                                     | Voltage and frequency control – Frequency measurement  | P              |
| 5.5.7.5                             | Reporting of NS protection   | P              |
| 5.5.9                               | Constructional characteristics of NS protection  | P              |
| 5.5.10.1                            | General  | P              |
| 5.5.10.2                            | Passive Islanding Protection   | N/A            |
| 5.5.10.3                            | Islanding protection according table 6 – Load imbalance (real, reactive load) for test condition A (PGU output = 100%) | P              |
|                                     | Islanding protection according table 6 – Load imbalance (real, reactive load) for test condition A (PGUT output = 66%) | P              |
|                                     | Islanding protection according table 6 – Load imbalance (real, reactive load) for test condition A (PGU output = 33%)  | P              |



| 5.5.2  |                       | NS protection     |               |                  |             |                  |               | P  |
|--|-----------------------|-------------------|---------------|------------------|-------------|------------------|---------------|--|
| The test for error detection with subsequent shutdown is carried out by means of error simulation, if necessary with additional error tests (see VDE-AR-N 4105: 2018-11, 6.1). |                       |                   |               |                  |             |                  |               |  |
| 5.5.2.1  |                       | Functional safety |               |                  |             |                  |               | P  |
| SOFAR 3300TL-G3  |                       |                   |               |                  |             |                  |               |  |
| Component No.  | Fault                 | Test condition:   |               | Test time: [min] | Fuse no.[A] | Fault condition: |               | Result:  |
|  |                       | AC                | DC            |                  |             | AC               | DC            |  |
| Relay detection failure<br>RYP2  | Short before start-up | 230V/<br>0,01A    | 360V/<br>0,1A | 10 mins          | --          | 230V/<br>0,01A   | 360V/<br>0,1A | The inverter cannot start-up.<br>Error message" RelayTestFail (The relays fault)"<br>No damage, No hazard.   |
| Relay detection failure<br>RYP3  | Short before start-up | 230V/<br>0,01A    | 360V/<br>0,1A | 10 mins          | --          | 230V/<br>0,01A   | 360V/<br>0,1A | The inverter cannot start-up.<br>Error message" RelayTestFail (The relays fault)"<br>No damage, No hazard.   |
| Relay detection failure<br>RYP4  | Short before start-up | 230V/<br>0,01A    | 360V/<br>0,1A | 10 mins          | --          | 230V/<br>0,01A   | 360V/<br>0,1A | The inverter cannot start-up.<br>Error message" RelayTestFail (The relays fault)"<br>No damage, No hazard.   |
| Relay detection failure<br>RYP5  | Short before start-up | 230V/<br>0,01A    | 360V/<br>0,1A | 10 mins          | --          | 230V/<br>0,01A   | 360V/<br>0,1A | The PCE cannot start-up.<br>Error message" RelayTestFail (The relays fault)".<br>No damage, No hazard.   |
| BUS voltage monitoring<br>RP2  | Short circuits        | 230V/<br>7,5A     | 360V/<br>5,0A | 10 mins          | --          | 230V/<br>0,01A   | 360V/<br>0,1A | The inverter shut down and disconnected immediately from grid. Error message" BusVoltZeroFault (The BUS voltage sampling error)" No damage, No hazard. |
| BUS voltage monitoring<br>RP4  | Open circuits         | 230V/<br>7,5A     | 360V/<br>5,0A | 10 mins          | --          | 230V/<br>0,01A   | 360V/<br>0,1A | The inverter shut down and disconnected immediately from grid. Error message" BusVoltZeroFault (The BUS voltage sampling error)" No damage, No hazard. |
| BUS voltage monitoring<br>RP30   | Short circuits        | 230V/<br>7,5A     | 360V/<br>5,0A | 10 mins          | --          | 230V/<br>0,01A   | 360V/<br>0,1A | The inverter shut down and disconnected immediately from grid. Error message" BusVoltZeroFault (The BUS voltage sampling error)" No damage, No hazard. |
| BUS voltage monitoring<br>RP32   | Open circuits         | 230V/<br>7,5A     | 360V/<br>5,0A | 10 mins          | --          | 230V/<br>0,01A   | 360V/<br>0,1A | The inverter shut down and disconnected immediately from grid. Error message" BusVoltZeroFault (The BUS voltage sampling error)" No damage, No hazard. |



|                                  |                                |                |               |         |    |                |               |  |
|----------------------------------|--------------------------------|----------------|---------------|---------|----|----------------|---------------|--|
| PV voltage monitoring<br>RP74    | Open circuits                  | 230V/<br>7,5A  | 360V/<br>5,0A | 10 mins | -- | 230V/<br>0,01A | 360V/<br>0,1A | The inverter shut down and disconnected immediately from grid. Error message" PVUVP (The input voltage is too low)" No damage, No hazard.    |
| PV voltage monitoring<br>RP75    | Short circuits                 | 230V/<br>7,5A  | 360V/<br>5,0A | 10 mins | -- | 230V/<br>0,01A | 360V/<br>0,1A | The inverter shut down and disconnected immediately from grid. Error message" PVOVP (The input voltage is too high)" No damage, No hazard.   |
| PV voltage monitoring<br>RP53    | Open circuits                  | 230V/<br>7,5A  | 360V/<br>5,0A | 10 mins | -- | 230V/<br>0,01A | 360V/<br>0,1A | The inverter shut down and disconnected immediately from grid. Error message" PVUVP (The input voltage is too low)" No damage, No hazard.    |
| PV voltage monitoring<br>RP55    | Short circuits                 | 230V/<br>7,5A  | 360V/<br>5,0A | 10 mins | -- | 230V/<br>0,01A | 360V/<br>0,1A | The inverter shut down and disconnected immediately from grid. Error message" PVOVP (The input voltage is too high)" No damage, No hazard.   |
| ISO detection failure<br>RP59    | Short circuits before start-up | 230V/<br>0,01A | 360V/<br>0,1A | 10 mins | -- | 230V/<br>0,01A | 360V/<br>0,1A | The inverter cannot start-up. Error message" PvlsoFault (The insulation resistance is too low)" No damage, No hazard.                        |
| ISO detection failure<br>RP130   | Open circuits                  | 230V/<br>0,01A | 360V/<br>0,1A | 10 mins | -- | 230V/<br>0,01A | 360V/<br>0,1A | The inverter cannot start-up. Error message" PvlsoFault (The insulation resistance is too low)" No damage, No hazard.                        |
| ISO detection failure<br>RP70    | Short circuits                 | 230V/<br>0,01A | 360V/<br>0,1A | 10 mins | -- | 230V/<br>0,01A | 360V/<br>0,1A | The inverter cannot start-up. Error message" PvlsoFault (The insulation resistance is too low)" No damage, No hazard.                        |
| Grid voltage monitoring<br>RP87  | Short circuits                 | 230V/<br>7,5A  | 360V/<br>5,0A | 10 mins | -- | 230V/<br>0,01A | 360V/<br>0,1A | The inverter shut down and disconnected immediately from grid. Error message" HwADFaultVGrid (The grid voltage fault)" No damage, No hazard. |
| Grid voltage monitoring<br>RP88  | Open circuits                  | 230V/<br>7,5A  | 360V/<br>5,0A | 10 mins | -- | 230V/<br>0,01A | 360V/<br>0,1A | The inverter shut down and disconnected immediately from grid. Error message" HwADFaultVGrid (The grid voltage fault)" No damage, No hazard. |
| Grid voltage monitoring<br>RP102 | Short circuits                 | 230V/<br>7,5A  | 360V/<br>5,0A | 10 mins | -- | 230V/<br>0,01A | 360V/<br>0,1A | The inverter shut down and disconnected immediately from grid. Error message" HwADFaultVGrid (The grid voltage fault)" No damage, No         |



|   |                |               |               |         |    |                |               |  |
|---|----------------|---------------|---------------|---------|----|----------------|---------------|--|
|   |                |               |               |         |    |                |               | hazard.  |
| Grid voltage monitoring<br>RP104          | Open circuits  | 230V/<br>7,5A | 360V/<br>5,0A | 10 mins | -- | 230V/<br>0,01A | 360V/<br>0,1A | The inverter shut down and disconnected immediately from grid. Error message" HwADFaultVGrid (The grid voltage fault)" No damage, No hazard. |
| XL2<br>pin3 to pin4                       | Short circuits | 230V/<br>7,5A | 360V/<br>5,0A | 10 mins | -- | 230V/<br>0,01A | 360V/<br>0,1A | The inverter shut down and disconnected immediately from grid.<br>No damage, No hazard.  |
| U6<br>pin32 to pin32                      | Short circuits | 230V/<br>7,5A | 360V/<br>5,0A | 10 mins | -- | 230V/<br>0,01A | 360V/<br>0,1A | The inverter shut down and disconnected immediately from grid.<br>No damage, No hazard.  |
| PV voltage monitoring<br>RC7              | Short circuits | 230V/<br>7,5A | 360V/<br>5,0A | 10 mins | -- | 230V/<br>0,01A | 360V/<br>0,1A | The inverter shut down and disconnected immediately from grid. Error message" PVOVP (The input voltage is too high)" No damage, No hazard.   |
| PV voltage monitoring<br>U5A pin1 to pin4 | Short circuits | 230V/<br>7,5A | 360V/<br>5,0A | 10 mins | -- | 230V/<br>0,01A | 360V/<br>0,1A | The inverter shut down and disconnected immediately from grid. Error message" PVOVP (The input voltage is too high)" No damage, No hazard.   |
| PV voltage monitoring<br>RC23             | Short circuits | 230V/<br>7,5A | 360V/<br>5,0A | 10 mins | -- | 230V/<br>0,01A | 360V/<br>0,1A | The inverter shut down and disconnected immediately from grid. Error message" PVOVP (The input voltage is too high)" No damage, No hazard.   |
| GFCI detection failure<br>RC152           | Short circuits | 230V/<br>7,5A | 360V/<br>5,0A | 10 mins | -- | 230V/<br>0,01A | 360V/<br>0,1A | The inverter shut down and disconnected immediately from grid. Error message" GFCIFault (GFCI Fault)" No damage, No hazard.                  |
| GFCI detection failure<br>RC142           | Short circuits | 230V/<br>7,5A | 360V/<br>5,0A | 10 mins | -- | 230V/<br>0,01A | 360V/<br>0,1A | The inverter shut down and disconnected immediately from grid. Error message" GFCIFault (GFCI Fault)" No damage, No hazard.                  |
| GFCI detection failure<br>U6C             | Short circuits | 230V/<br>7,5A | 360V/<br>5,0A | 10 mins | -- | 230V/<br>0,01A | 360V/<br>0,1A | The inverter shut down and disconnected immediately from grid. Error message" GFCIFault (GFCI Fault)" No damage, No hazard.                  |
| GFCI detection failure<br>RC24            | Short circuits | 230V/<br>7,5A | 360V/<br>5,0A | 10 mins | -- | 230V/<br>0,01A | 360V/<br>0,1A | The inverter shut down and disconnected immediately from grid. Error message" GFCIFault (GFCI Fault)" No damage, No hazard.                  |
| GFCI detection                            | Short          | 230V/<br>7,5A | 360V/<br>5,0A | 10      | -- | 230V/<br>0,01A | 360V/<br>0,1A | The inverter shut down and   |



|   |                                |                |               |         |    |                |               |  |
|---|--------------------------------|----------------|---------------|---------|----|----------------|---------------|--|
| failure<br>RC63                                   | circuits                       | 7,5A           | 5,0A          | mins    |    | 0,01A          | 0,1A          | disconnected immediately from grid. Error message" GFCIFault (GFCI Fault)" No damage, No hazard.   |
| ISO detection failure<br>RC113                    | Short circuits before start-up | 230V/<br>0,01A | 360V/<br>0,1A | 10 mins | -- | 230V/<br>0,01A | 360V/<br>0,1A | The inverter cannot start-up. Error message" PvIsoFault (The insulation resistance is too low)" No damage, No hazard.                                  |
| GFCI detection failure<br>U6D pin12 to pin 14     | Short circuits before start-up | 230V/<br>0,01A | 360V/<br>0,1A | 10 mins | -- | 230V/<br>0,01A | 360V/<br>0,1A | The inverter cannot start-up. Error message" PvIsoFault (The insulation resistance is too low)" No damage, No hazard.                                  |
| GFCI detection failure<br>102                     | Short circuits before start-up | 230V/<br>0,01A | 360V/<br>0,1A | 10 mins | -- | 230V/<br>0,01A | 360V/<br>0,1A | The inverter cannot start-up. Error message" PvIsoFault (The insulation resistance is too low)" No damage, No hazard.                                  |
| BUS voltage detection failure<br>RC73             | Short circuits                 | 230V/<br>7,5A  | 360V/<br>5,0A | 10 mins | -- | 230V/<br>0,01A | 360V/<br>0,1A | The inverter shut down and disconnected immediately from grid. Error message" BusVoltZeroFault (The BUS voltage sampling error)" No damage, No hazard. |
| BUS voltage detection failure<br>RC79             | Open circuits                  | 230V/<br>7,5A  | 360V/<br>5,0A | 10 mins | -- | 230V/<br>0,01A | 360V/<br>0,1A | The inverter shut down and disconnected immediately from grid. Error message" BusVoltZeroFault (The BUS voltage sampling error)" No damage, No hazard. |
| BUS voltage detection failure<br>U6A pin3 to pin1 | Short circuits                 | 230V/<br>7,5A  | 360V/<br>5,0A | 10 mins | -- | 230V/<br>0,01A | 360V/<br>0,1A | The inverter shut down and disconnected immediately from grid. Error message" BusVoltZeroFault (The BUS voltage sampling error)" No damage, No hazard. |
| BUS voltage detection failure<br>RC85             | Short circuits                 | 230V/<br>7,5A  | 360V/<br>5,0A | 10 mins | -- | 230V/<br>0,01A | 360V/<br>0,1A | The inverter shut down and disconnected immediately from grid. Error message" BusVoltZeroFault (The BUS voltage sampling error)" No damage, No hazard. |
| Grid current detection failure<br>RC2             | Short circuits                 | 230V/<br>7,5A  | 360V/<br>5,0A | 10 mins | -- | 230V/<br>0,01A | 360V/<br>0,1A | The inverter shut down and disconnected immediately from grid. Error message" HwADFaultIGrid (The grid current sampling error)" No damage, No hazard.  |
| Grid current detection failure<br>RC14            | Short circuits                 | 230V/<br>7,5A  | 360V/<br>5,0A | 10 mins | -- | 230V/<br>0,01A | 360V/<br>0,1A | The inverter shut down and disconnected immediately from grid. Error message" HwADFaultIGrid (The grid current sampling error)" No                     |



|  |                |               |               |         |    |                |               |   |
|--|----------------|---------------|---------------|---------|----|----------------|---------------|---|
|  |                |               |               |         |    |                |               | damage, No hazard.  |
| Grid current detection failure<br>RC20 | Open circuits  | 230V/<br>7,5A | 360V/<br>5,0A | 10 mins | -- | 230V/<br>0,01A | 360V/<br>0,1A | The inverter shut down and disconnected immediately from grid. Error message" HwADFaultIGrid (The grid current sampling error)" No damage, No hazard.                           |
| Grid current detection failure<br>RC16 | Short circuits | 230V/<br>7,5A | 360V/<br>5,0A | 10 mins | -- | 230V/<br>0,01A | 360V/<br>0,1A | The inverter shut down and disconnected immediately from grid. Error message" HwADFaultIGrid (The grid current sampling error)" No damage, No hazard.                           |
| Grid current detection failure<br>RC27 | Short circuits | 230V/<br>7,5A | 360V/<br>5,0A | 10 mins | -- | 230V/<br>0,01A | 360V/<br>0,1A | The inverter shut down and disconnected immediately from grid. Error message" HwADFaultIGrid (The grid current sampling error)" No damage, No hazard.                           |
| Grid current detection failure<br>RC21 | Short circuits | 230V/<br>7,5A | 360V/<br>5,0A | 10 mins | -- | 230V/<br>0,01A | 360V/<br>0,1A | The inverter shut down and disconnected immediately from grid. Error message" HwADFaultIGrid (The grid current sampling error)" No damage, No hazard.                           |
| Grid current detection failure<br>RC28 | Short circuits | 230V/<br>7,5A | 360V/<br>5,0A | 10 mins | -- | 230V/<br>0,01A | 360V/<br>0,1A | The inverter shut down and disconnected immediately from grid. Error message" HwADFaultIGrid (The grid current sampling error)" No damage, No hazard.                           |
| Grid current detection failure<br>RC21 | Short circuits | 230V/<br>7,5A | 360V/<br>5,0A | 10 mins | -- | 230V/<br>0,01A | 360V/<br>0,1A | The inverter shut down and disconnected immediately from grid. Error message" HwADFaultIGrid (The grid current sampling error)" No damage, No hazard.                           |
| Grid current detection failure<br>RC18 | Short circuits | 230V/<br>7,5A | 360V/<br>5,0A | 10 mins | -- | 230V/<br>0,01A | 360V/<br>0,1A | The inverter shut down and disconnected immediately from grid. Error message" HwADFaultIGrid (The grid current sampling error)" No damage, No hazard.                           |
| Grid current detection failure<br>CC52 | Short circuits | 230V/<br>7,5A | 360V/<br>5,0A | 10 mins | -- | 230V/<br>0,01A | 360V/<br>0,1A | The inverter shut down and disconnected immediately from grid. Error message" HwAcOCP (The grid current is too high, and has happen hardware protection)" No damage, No hazard. |
| Grid current detection failure<br>CC48 | Short circuits | 230V/<br>7,5A | 360V/<br>5,0A | 10 mins | -- | 230V/<br>0,01A | 360V/<br>0,1A | The inverter shut down and disconnected immediately from grid. Error message" HwAcOCP (The grid current   |



|  |                |               |               |         |    |                |               |  |
|--|----------------|---------------|---------------|---------|----|----------------|---------------|--|
|  |                |               |               |         |    |                |               | is too high, and has happen hardware protection)" No damage, No hazard.  |
| DCI detection failure<br>UC3C pin9 to pin8   | Short circuits | 230V/<br>7,5A | 360V/<br>5,0A | 10 mins | -- | 230V/<br>0,01A | 360V/<br>0,1A | The inverter shut down and disconnected immediately from grid. Error message" HwADFaultDCI (The DCI sampling error)" No damage, No hazard.     |
| DCI detection failure<br>RC118               | Short circuits | 230V/<br>7,5A | 360V/<br>5,0A | 10 mins | -- | 230V/<br>0,01A | 360V/<br>0,1A | The inverter shut down and disconnected immediately from grid. Error message" HwADFaultDCI (The DCI sampling error)" No damage, No hazard.     |
| DCI detection failure<br>UC3D pin12 to pin14 | Short circuits | 230V/<br>7,5A | 360V/<br>5,0A | 10 mins | -- | 230V/<br>0,01A | 360V/<br>0,1A | The inverter shut down and disconnected immediately from grid. Error message" HwADFaultDCI (The DCI sampling error)" No damage, No hazard.     |
| DCI detection failure<br>CC29                | Short circuits | 230V/<br>7,5A | 360V/<br>5,0A | 10 mins | -- | 230V/<br>0,01A | 360V/<br>0,1A | The inverter shut down and disconnected immediately from grid. Error message" HwADFaultDCI (The DCI sampling error)" No damage, No hazard.     |
| DCI detection failure<br>RC33                | Short circuits | 230V/<br>7,5A | 360V/<br>5,0A | 10 mins | -- | 230V/<br>0,01A | 360V/<br>0,1A | The inverter shut down and disconnected immediately from grid. Error message" HwADFaultDCI (The DCI sampling error)" No damage, No hazard.     |
| GFCI detection failure<br>QC4 pin3 to pin2   | Short circuits | 230V/<br>7,5A | 360V/<br>5,0A | 10 mins | -- | 230V/<br>0,01A | 360V/<br>0,1A | The inverter shut down and disconnected immediately from grid. Error message" GFCIDeviceFault (The GFCI sampling error)" No damage, No hazard. |
| GFCI detection failure<br>QC4 pin3 to pin2   | Short circuits | 230V/<br>7,5A | 360V/<br>5,0A | 10 mins | -- | 230V/<br>0,01A | 360V/<br>0,1A | The inverter shut down and disconnected immediately from grid. Error message" GFCIDeviceFault (The GFCI sampling error)" No damage, No hazard. |
| GFCI detection failure<br>RC98               | Short circuits | 230V/<br>7,5A | 360V/<br>5,0A | 10 mins | -- | 230V/<br>0,01A | 360V/<br>0,1A | The inverter shut down and disconnected immediately from grid. Error message" GFCIDeviceFault (The GFCI sampling error)" No damage, No hazard. |
| Communication loss                           | Open circuits  | 230V/<br>7,5A | 360V/<br>5,0A | 10 mins | -- | 230V/<br>0,01A | 360V/<br>0,1A | The inverter shut down and disconnected immediately from grid. Error message"  |



|                                  |               |               |               |         |    |                |               |  |
|----------------------------------|---------------|---------------|---------------|---------|----|----------------|---------------|--|
| UC34 pin33                       |               |               |               |         |    |                |               | SpiCommLose (The spi communication between the master and slave DSP is fault)" No damage, No hazard.   |
| Communication loss<br>UC34 pin32 | Open circuits | 230V/<br>7,5A | 360V/<br>5,0A | 10 mins | -- | 230V/<br>0,01A | 360V/<br>0,1A | The inverter shut down and disconnected immediately from grid. Error message" SpiCommLose (The spi communication between the master and slave DSP is fault)" No damage, No hazard. |

**Note:**

The errors in the control circuit simulate that the safety is even ensured during a single fault.

The tests had been performed on the SOFAR 3300TL-G3 is valid for the SOFAR 1100TL-G3, SOFAR 1600TL-G3, SOFAR 2200TL-G3, SOFAR 2700TL-G3 and SOFAR 3000TL-G3 since it is same as in hardware and just power derated by software.

**Assessment criterion:**

The NA protection must send a shutdown command to the coupling switch.

If the error is detected, the device is switched off within 10 s after error detection.


If the auxiliary voltage fails with the central NA protection or if the control fails with the integrated NA protection, the switch-off command must be given immediately.

| 5.5.4  | Integrated NS protection | P |
|--|--------------------------|---|
| The integrated NA protection is tested in 5.5.7 and in connection with the examination of the entire NS protection chain and switch. |                          |   |
| <b>Note:</b><br>For test results see 5.5.2.1 Functional safety.  |                          |   |



|  |  |   |
|--|--|---|
| 5.5.6.3  | Integrated interface switch  | P |
| 5.5.6.3.1  | Test (functional chain integrated NS-protection and integrated interface switch) | P |
| <b>Following monitoring options of an interface switch are valid (a) or (b) or (c):</b>  |  |   |
| <b>(a) Use of a interface switch in which a control voltage must be constantly applied when switched on and which switches off automatically when this voltage is not present. The operational switch-on and switch-off processes is monitored</b> |  |   |
| The disconnection of the control voltage leads to the instantaneous disconnection of the interface switch.   |  | P |
| A simulated defect during the closing and opening of the interface switch leads to an instantaneous shutdown of the PGU. A restart is not possible.  |  | P |
| A simulated defect of the interface switch after the NS protection as operated leads to an instantaneous shutdown of the PGU. A restart is not possible.   |  | P |
| The switch-off time of the whole reaction chain is within 200ms.   |  | P |
| <b>(b) The interface switch is switched on and off at least once a day by the NS protection and the proper functioning of the coupling switch is monitored.</b>  |  |   |
| A simulated defect of the interface switch during the daily test leads to an instantaneous shutdown of the PGU. A restart is not possible.   |  | P |
| A simulated defect of the interface switch after the NS protection has operated leads to an instantaneous shutdown of the PGU. A restart is not possible.  |  | P |
| A function for daily switching on and off is available and explained by a manufacturer's declaration.  |  | P |
| <b>(c) Use of the integrated coupling switch and the integrated NA protection for PV and battery converters according to DIN EN 62109 (VDE 0126-14-1).</b>   |  |   |
| The integrated interface switch and NS protection is comply with DIN EN 62109 (VDE 0126-14-1).<br>See vde 0126 test report 19041074GZU-003 tested by Intertek Testing Services Shenzhen Ltd.Guangzhou Branch at Oct.31.2019.                       |  | P |
| <b>Note:</b><br>See test results 5.5.2.1 functional safety.  |  |   |
| The inverter has a galvanic separating break device.<br>The interface switch is short-circuit proof for the maximum short-circuit current of the power generation unit.  |  |   |
| Max. initial short-circuit current of the PGU (power generation unit)  | = 40A, 277Vac  |   |
| Max. switching current relay   | = 33 A, 277Vac   |   |

Datasheet of the relay (interface protection relay / Interface switch):

 产品规格书 Specification

产品规格书 Relay Specification

顾客 Customer: 首航

1 品种 Type Model

- 1.1 种类 Kinds: 电磁继电器 Electromagnetic Relay  
 1.2 型号 Type: HF161F-W/12-HT(477)  
 1.3 外形尺寸 Outline: 30.4mm×15.9mm×23.3mm  
 1.4 触点形式 Contact Arrangement: 一组常开 1 Form A  
 1.5 触点材料 Contact Material: AgSnO2  
 1.6 触点间隙 Contact Gap: ≥1.8 mm

2 安全认证 Safety Approval

| 认证机构 Certification Agency | 认证号 File No.   |
|---------------------------|----------------|
| UL/CUL                    | E134517        |
| VDE                       | 40031410       |
| CQC                       | CQC10002050943 |

上述认证号代表该产品取得相关认证,但具体认证内容请以我公司提交的认证证书为准。The above certificate No. is just a license No. Please refer to the certificates we supplied for detail information.

3 线圈额定参数 Coil Rating

at 23 °C

| 额定电压<br>Rated Voltage<br>Vd. c. | 动作电压<br>Operate Voltage<br>Vd. c. | 释放电压<br>Release Voltage<br>Vd. c. | 保持电压<br>Holding Voltage<br>Vd. c.                                       | 线圈电阻<br>Coil Resistance<br>Ω | 线圈功耗<br>Coil Power<br>W<br>大约 Approx. | 线圈电流<br>Coil Current<br>A      |
|---------------------------------|-----------------------------------|-----------------------------------|---|------------------------------|---------------------------------------|--------------------------------|
| 12                              | ≤8.4                              | ≥1.2                              | 35%~120% U <sub>c</sub> (at 23 °C)<br>45%~80% U <sub>c</sub> (at 85 °C) | 103×(1±10%)                  | 1.4                                   | 116.5 mA (标称值 nominal current) |

注 1: 线圈保持电压为从线圈施加额定电压 100 ms 以后的线圈电压。

Note 1: The coil holding voltage is the voltage of coil after being applied nominal voltage for 100 ms.

注 2: 磁路系统专门设计用于这种低保持功耗, 当环境温度大于 23℃ 时, 如果不降低线圈功耗, 则不允许长期使用!

Note 2: The magnetic system is designed for this reduced holding power, continuous operation without power reduction is not permitted for ambient temperatures of > 23° C!

**HF** 产品规格书 Specification

**4 触点参数 Contact Specification**

- 4.1 触点额定负载 Contact Rating: 26 A, 277 Va.c.  
 4.2 最大切换电流 Max. Switching Current: 33 A  
 4.3 最大切换电压 Max. Switching Voltage: 277 Va.c.  
 4.4 最小适用负载 Min. Applicable Load: 6 V, 1 A

**5 性能 Performance**

5.1 接触电阻 Contact Resistance: 100 mΩ max. (at 6 Vd.c. 1A)。(四端法 Four Probe Method)

5.2 动作时间 Operate Time: ≤ 20 ms。

5.3 释放时间 Release Time: ≤ 10 ms。

5.4 回跳时间 Bounce Time: ≤ 10 ms。

**5.5 耐久性 Endurance**

**5.5.1 电耐久性 Electrical Endurance**

| 结构型式<br>Version | 触点材料<br>Contact<br>Material | 触点负载<br>Contact Rating                   | 环境温度<br>Ambient<br>Temperature | 通断比<br>ON: OFF  | 电耐久性<br>Electrical<br>Endurance |
|-----------------|-----------------------------|--|--------------------------------|-----------------|---------------------------------|
| IH              | AgSnO <sub>2</sub>          | 阻性负载<br>resistive Load<br>26 A 277 Va.c. | 常温<br>Room<br>Temperature      | 1.5 s:<br>1.5 s | 3×10 <sup>6</sup> 次 (ops)       |

**5.5.2 机械耐久性 Mechanical Endurance**

| 结构型式<br>Version | 触点负载<br>Contact Rating | 环境温度<br>Ambient Temperature | 通断比<br>ON: OFF | 机械耐久性<br>Mechanical<br>Endurance |
|-----------------|------------------------|-----------------------------|----------------|----------------------------------|
| IH              | 无负载<br>No load         | 室温<br>Room Temperature      | 0.5 s: 0.5 s   | 2×10 <sup>6</sup> 次 (ops)        |

**5.6 介质耐压 Dielectric Strength (漏电流 Leak Current: 1 mA)**

5.6.1 断开触点电路的各引出端之间 Between terminals of each opened contact circuit: 2500 Va.c. (50/60 Hz 1 min)。

5.6.2 所有触点电路引出端与所有线圈引出端之间 Between all contact circuit terminals and all coil terminals: 4500 Va.c. (50/60 Hz 1 min)。

**5.7 绝缘电阻 Insulation Resistance**

5.7.1 断开触点电路的各引出端之间 Between terminals of each opened contact circuit: 1000 MΩ (500 Vd.c.)。

5.7.2 所有触点电路引出端与所有线圈引出端之间 Between all contact circuit terminals and all coil terminals: 1000 MΩ (500 Vd.c.)。

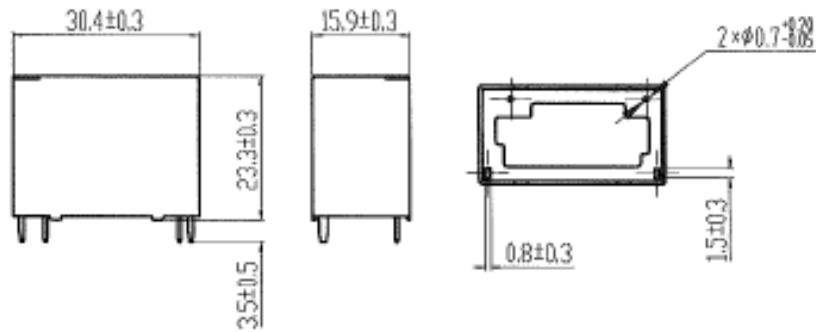
**5.8 线圈温升 Coil Temperature Rise: 70 K max.**

以100%额定电压激励100 ms后降为80%额定电压保持, 触点负载26 A 277 Va.c., 环境温度: 85 ℃。

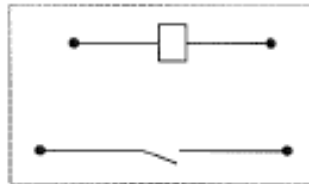
HF 产品规格书 Specification

10 产品结构 Configuration

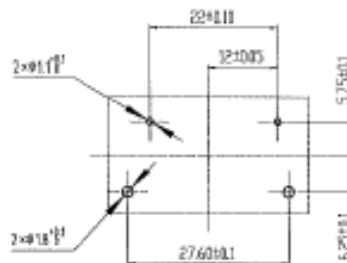
10.1 外形图 Outline Schematic



10.2 接线图 Wiring Diagram



10.3 安装孔位图 PCB Layout



注：产品外形尺寸未注尺寸公差及 PC 板未注尺寸公差按下表执行。

Note: All unspecified tolerance (including outline dimension and PC board dimension) according to following table.

| 产品外形尺寸未注尺寸公差<br>Outline dimensions hadn't specified tolerance |                 | PC 板未注尺寸公差<br>PC board dimensions hadn't specified tolerance |
|---|-----------------|--|
| 外形尺寸<br>Outline Dimensions                                    | 公差<br>Tolerance | ±0.1   |
| ≤1  | ±0.2            |  |

|   |                                |                       |                          |                      |                          |          |
|---|--------------------------------|-----------------------|--------------------------|----------------------|--------------------------|----------|
| <b>5.5.7.2</b>  | <b>Check of setting values</b> |                       |                          |                      |                          | <b>P</b> |
| <b>5.5.7.2.1</b>  | <b>Test</b>                    |                       |                          |                      |                          | <b>P</b> |
| <b>SOFAR 3300TL-G3</b>  |                                |                       |                          |                      |                          |          |
| <b>Setting values:</b>  |                                |                       |                          |                      |                          |          |
| <b>PGU type</b>   | <b>Description</b>             | <b>Parameter name</b> | <b>Set value in p.u.</b> | <b>Set value L-N</b> | <b>Set value L-L *2)</b> |          |
|   | nominal voltage                | $U_n$                 | 1                        | 230,0 V              | 400 V                    |          |
|   | Nominal frequency              | $f_n$                 | 1                        | 50 Hz                | 50 Hz                    |          |
| a) name set of parameter (Parameter setup name in manual or software)   |                                |                       |                          |                      |                          |          |
| Stirling generators, fuel cells,<br>coupled directly or via a converter<br>Synchronous and asynchronous generators<br>with $P_n \leq 50$ kW | Excitation threshold $U_{>>}$  | $AU_{>>}$             | 1,15                     | 264,5V               | 460V                     |          |
|   | Delay time $U_{>>}$            | $tU_{>>}$             | -                        | 100ms                | 100ms                    |          |
|   | Excitation threshold $U_{>}$   | $AU_{>}$              | 1,10                     | 253,0V               | 440V                     |          |
|   | Delay time $U_{>} * 1)$        | $tU_{>}$              | -                        | 100ms *1)            | 100ms *1)                |          |
|   | Excitation threshold $U_{<}$   | $AU_{<}$              | 0,8                      | 184,0 V              | 320V                     |          |
|   | Delay time $U_{<}$             | $tU_{<}$              | -                        | 100ms                | 100ms                    |          |
|   | Excitation threshold $U_{<<}$  | $AU_{<<}$             | deactivated              | -                    | -                        |          |
|   | Delay time $U_{<<}$            | $tU_{<<}$             | deactivated              | -                    | -                        |          |
|   | Excitation threshold $f_{>}$   | $Af_{>}$              | 1,03                     | 51,5Hz               | 51,5Hz                   |          |
|   | Delay time $f_{>}$             | $tf_{>}$              | -                        | 100ms                | 100ms                    |          |
|   | Excitation threshold $f_{<}$   | $Af_{<}$              | 0,95                     | 47,5Hz               | 47,5Hz                   |          |
|   | Delay time $f_{<}$             | $tf_{<}$              | -                        | 100ms                | 100ms                    |          |
| b) name set of parameter (Parameter setup name in manual or software)   |                                |                       |                          |                      |                          |          |
| directly coupled synchronous and<br>asynchronous generators with $P_n > 50$ kW  | Excitation threshold $U_{>>}$  | $AU_{>>}$             | 1,25                     | 287,5V               | 500V                     |          |
|   | Delay time $U_{>>}$            | $tU_{>>}$             | -                        | 100ms                | 100ms                    |          |
|   | Excitation threshold $U_{>}$   | $AU_{>}$              | 1,10                     | 253,0V               | 440V                     |          |
|   | Delay time $U_{>} * 1)$        | $tU_{>}$              | -                        | 100ms *1)            | 100ms *1)                |          |
|   | Excitation threshold $U_{<}$   | $AU_{<}$              | 0,8                      | 184,0V               | 320V                     |          |
|   | Delay time $U_{<}$             | $tU_{<}$              | -                        | 1s                   | 1s                       |          |
|   | Excitation threshold $U_{<<}$  | $AU_{<<}$             | 0,45                     | 103,5V               | 180V                     |          |
|   | Delay time $U_{<<}$            | $tU_{<<}$             | -                        | 300ms                | 300ms                    |          |
|   | Excitation threshold $f_{>}$   | $Af_{>}$              | 1,03                     | 51,5Hz               | 51,5Hz                   |          |
|   | Delay time $f_{>}$             | $tf_{>}$              | -                        | 100ms                | 100ms                    |          |
|   | Excitation threshold $f_{<}$   | $Af_{<}$              | 0,95                     | 47,5Hz               | 47,5Hz                   |          |
|   | Delay time $f_{<}$             | $tf_{<}$              | -                        | 100ms                | 100ms                    |          |

| c) name set of parameter (Parameter setup name in manual or software)   |                          |      |      |           |           |
|---|--------------------------|------|------|-----------|-----------|
| Inverter  | Excitation threshold U>> | AU>> | 1,25 | 287,5V    | 500V      |
|   | Delay time U>>           | tU>> | -    | 100ms     | 100ms     |
|   | Excitation threshold U>  | AU>  | 1,10 | 253,0V    | 440V      |
|   | Delay time U> * 1)       | tU>  | -    | 100ms *1) | 100ms *1) |
|   | Excitation threshold U<  | AU<  | 0,8  | 184,0V    | 320V      |
|   | Delay time U<            | tU<  | -    | 3s        | 3s        |
|   | Excitation threshold U<< | AU<< | 0,45 | 103,5V    | 180V      |
|   | Delay time U<<           | tU<< | -    | 300ms     | 300ms     |
|   | Excitation threshold f>  | Af>  | 1,03 | 51,5Hz    | 51,5Hz    |
|   | Delay time f>            | tf>  | -    | 100ms     | 100ms     |
|   | Excitation threshold f<  | Af<  | 0,95 | 47,5Hz    | 47,5Hz    |
|   | Delay time f<            | tf<  | -    | 100ms     | 100ms     |
| Factory settings correspond to the values in Table 36   |                          |      |      |           | P         |
| There are no factory settings. The information on the setting values in the instructions manual correspond to those in Table 36.  |                          |      |      |           | P         |
| External NS protection: settings and delay times are password protected settable  |                          |      |      |           | P         |
| External NS protection: It is possible to read the setting values without a tool  |                          |      |      |           | P         |
| Integrated NS protection: the setting values are visible via a data interface or display  |                          |      |      |           | P         |
| The limit values for U> can be set between 110% and 115% and, in the case of directly coupled synchronous and asynchronous generators with P <sub>RE</sub> >50kW, the time delay for U< and U<< can be set. All other limit values are protected against unauthorized access. |                          |      |      |           | P         |
| <b>Assessment criterion:</b>  |                          |      |      |           |           |
| The exam is passed if the following points are met:   |                          |      |      |           |           |
| The factory setting values correspond   |                          |      |      |           |           |
| a) With integrated NA protection of VDE-AR-N 4105: 2018-11, 6.5.2 Table 2 (see also Table 36).  |                          |      |      |           |           |
| b) With central NA protection, either the factory settings of VDE-AR-N 4105: 2018-11, 6.5.2, Table 2 (see also Table 36) or these values can be set.  |                          |      |      |           |           |
| - In the event of an operator input, the test object only goes into operation after settings have been selected.  |                          |      |      |           |           |
| The setting values that can be changed according to 4105: 2018-11, 6.5.1 and 6.5.2 can be set within the specified limits and are protected against unauthorized access.  |                          |      |      |           |           |
| The setting values that cannot be changed according to VDE-AR-N 4105: 2018-11, 6.5.1 and 6.5.2 cannot be changed or are protected from unauthorized access by an additional separate protection system  |                          |      |      |           |           |

|   |   |           |           |                              |           |           |          |
|---|---|-----------|-----------|------------------------------|-----------|-----------|----------|
| <b>5.5.7.4</b>  | <b>Voltage and frequency control</b>                |           |           |                              |           |           | <b>P</b> |
| <b>5.5.7.4.1</b>  | <b>Voltage and frequency control – Single Phase</b> |           |           |                              |           |           | <b>P</b> |
| <b>Integrated NS protection single phase ≤30kVA</b>   |   |           |           |                              |           |           |          |
| Setting values of the NS protection:  | Setting   | Value [V] | Time [ms] | Setting                      | Value [V] | Time [ms] |          |
|   | U>  | 287,5     | 100       | /                            |           |           |          |
|   | U<  | 184,0     | 3000      |                              |           |           | U<<      |
| <b>Operating time of the monitoring device:</b>   |   |           |           |                              |           |           |          |
| <b>SOFAR 3300TL-G3</b>  |   |           |           |                              |           |           |          |
| <b>L1 to N:</b>   | <b>Under voltage 1 (4.2):</b>                       |           |           | <b>Over voltage 1 (1.2):</b> |           |           |          |
| Ramp [start V to stop V]  | >188,6 → <179,4                                     |           |           | <282,9 → >292,1              |           |           |          |
| Step size [V]   | <1,15   |           |           | <1,15                        |           |           |          |
| Step length [s]   | >3,200  |           |           | >0,400                       |           |           |          |
| Limit [V]   | 184,0 ±1% U <sub>n</sub>                            |           |           | 287,5 ±1% U <sub>n</sub>     |           |           |          |
| Measurement [V]   | 184,5   | 184,6     | 184,4     | 287,0                        | 287,2     | 287,1     |          |
| <b>L1 to N:</b>   | <b>Under voltage 1 (5.2):</b>                       |           |           | <b>Over voltage 1 (2.2):</b> |           |           |          |
| Jump [start V to stop V]  | >200,1 → <179,4                                     |           |           | <282,9 → >292,1              |           |           |          |
| Step size [V]   | >9,2  |           |           | >9,2                         |           |           |          |
| Step length [s]   | >3,200  |           |           | >0,400                       |           |           |          |
| Limit [s]   | 3,000 ≤t ≤3,100                                     |           |           | 0,100 ≤t ≤0,200              |           |           |          |
| Measurement [s]   | 3070  | 3070      | 3067      | 108                          | 102       | 108       |          |
| <b>L1 to N:</b>   | <b>Under voltage 2 (6.2):</b>                       |           |           | /                            |           |           |          |
| Ramp [start V to stop V]:   | >108,1 → <98,9                                      |           |           |                              |           |           |          |
| Step size [V]   | <1,15   |           |           |                              |           |           |          |
| Step length [s]   | >0,500  |           |           |                              |           |           |          |
| Limit [V]:  | 103,5 ±1% U <sub>n</sub>                            |           |           |                              |           |           |          |
| Measurement [V:]  | 103,2   | 103,1     | 103,2     |                              |           |           |          |
| <b>L1 to N:</b>   | <b>Under voltage 2 (7.2):</b>                       |           |           | /                            |           |           |          |
| Jump [start V to stop V]:   | >108,1 → <98,9                                      |           |           |                              |           |           |          |
| Step size [V]   | >9,2  |           |           |                              |           |           |          |
| Step length [s]   | >0,500  |           |           |                              |           |           |          |
| Limit [s]:  | 0,300 ≤t ≤0,400                                     |           |           |                              |           |           |          |
| Measurement [s]:  | 382   | 370       | 397       |                              |           |           |          |
| <b>Note:</b>  |   |           |           |                              |           |           |          |
| The disconnection time includes disconnect time + operate time of the integrated relay. Therefore limit is give with +100ms according to Table 2 set values of the NS-protection according to VDE AR-N 4105:2018.               |   |           |           |                              |           |           |          |
| The permitted tolerance between setting value and trip value of the voltage may not exceed ±1% of U <sub>n</sub> .  |   |           |           |                              |           |           |          |
| The tests had been performed on the SOFAR 3300TL-G3 is valid for the SOFAR 1100TL-G3, SOFAR 1600TL-G3, SOFAR 2200TL-G3, SOFAR 2700TL-G3 and SOFAR 3000TL-G3 since it is same as in hardware and just power derated by software. |   |           |           |                              |           |           |          |

### Over voltage 1: L1 to N



### Under voltage 1: L1 to N



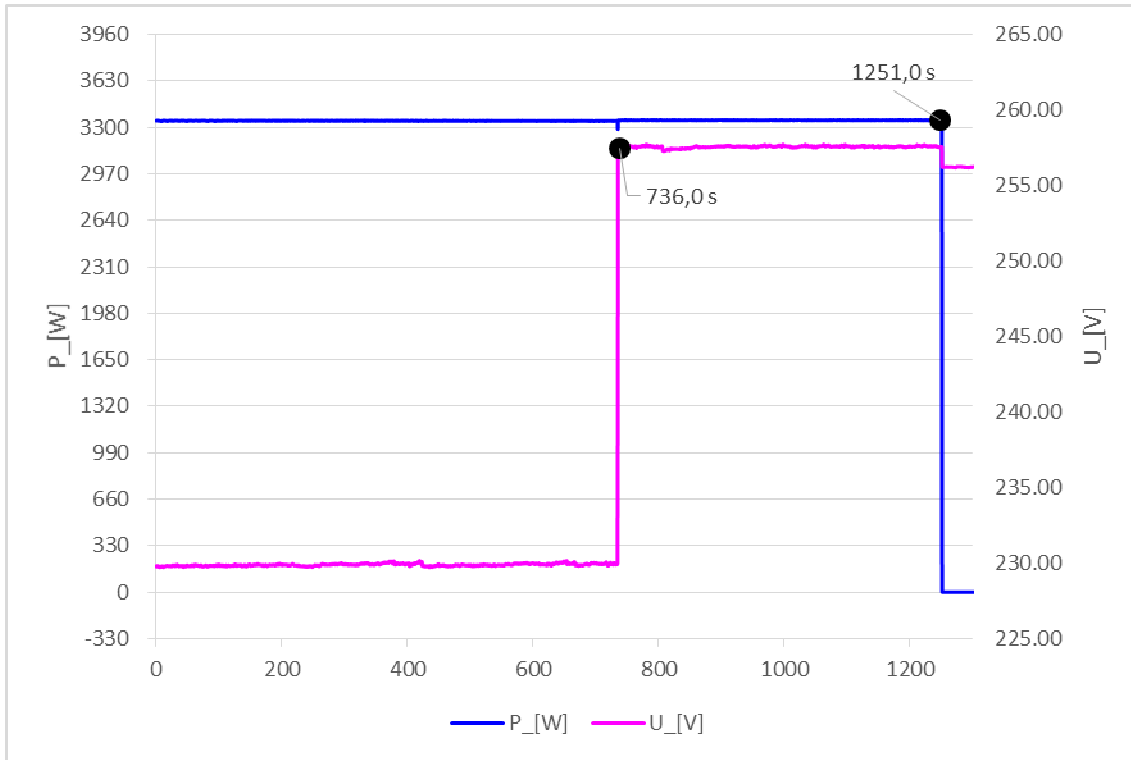


### Under voltage 2: L1 to N

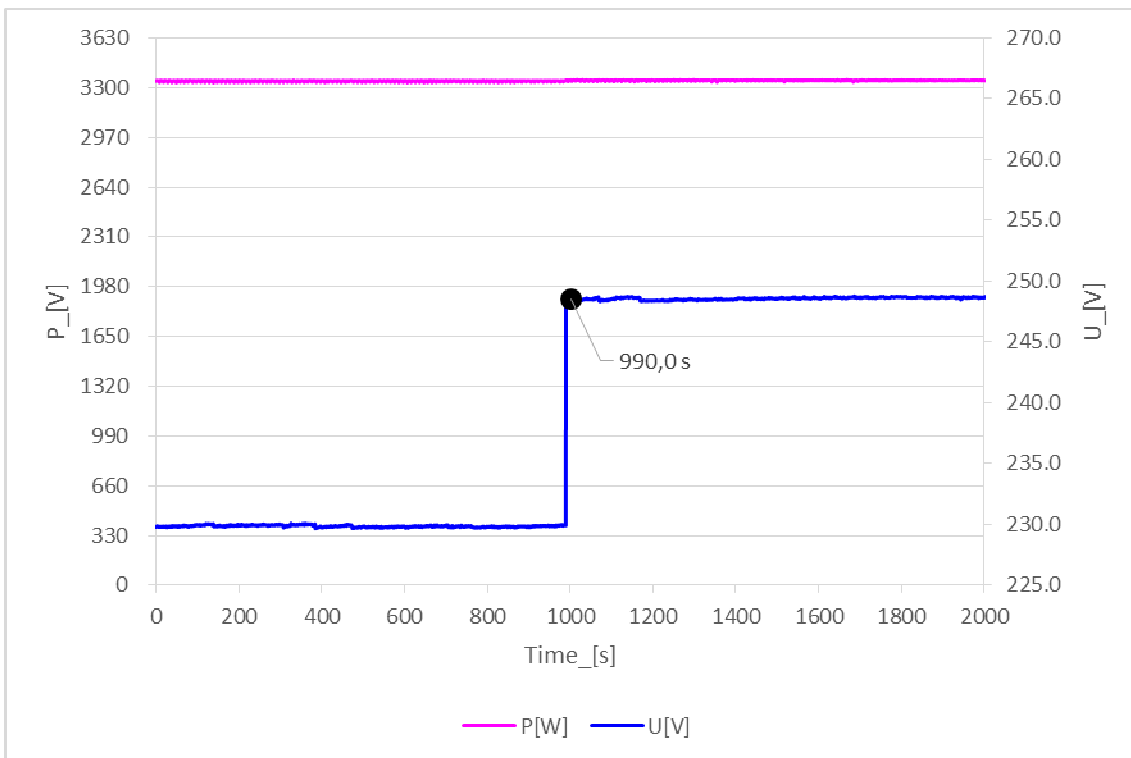


|   |   |          |
|---|---|----------|
| <b>5.5.7.4</b>  | <b>Voltage and frequency control</b>  | <b>P</b> |
| <b>5.5.7.4.1</b>  | <b>Voltage and frequency control – Measuring the rise-in voltage protection as a running 10-minute mean value</b> | <b>P</b> |
| Setting values of the NS protection:  | Setting U <sub>&gt;</sub> [V]   | 253,0    |
|   | Setting T <sub>disconnection U<sub>&gt;</sub></sub> [s]   | /        |
|   | Setting T <sub>disconnection</sub> [ms]   | /        |
| <b>Operating time of the monitoring device:</b>   |   |          |
| <b>SOFAR 3300TL-G3</b>  |   |          |
| L1-N, L2-N, L3N:  | <b>Over voltage 10-minute mean value (3.1):</b>   |          |
| Ramp [start V to stop V]  | 230,0 → 257,6   |          |
| Step size [V]   | 27,6  |          |
| Step length [s]   | >600,2  |          |
| Limit for disconnection [s]   | 450 – 550   |          |
| Measurement [s]   | 515,0   |          |
| L1-N, L2-N, L3N:  | <b>Over voltage 10-minute mean value (3.2):</b>   |          |
| Ramp [start V to stop V]  | 230,0 → >248,4  |          |
| Step size [V]   | 18,4  |          |
| Step length [s]   | >600,2  |          |
| Limit for reconnection [s]  | no disconnection (also after 600s)  |          |
| Measurement [s]   | No disconnection  |          |
| L1-N or L2-N or L3N:  | <b>Over voltage 10-minute mean value (3.3):</b>   |          |
| Ramp [start V to stop V]  | 243,8 → >262,2  |          |
| Step size [V]   | 18,4  |          |
| Step length [s]   | >600,2  |          |
| Limit for disconnection[s]  | 225 – 375   |          |
| Measurement [s]   | 314,0   |          |
| <b>Note:</b>  |   |          |
| The tests had been performed on the SOFAR 3300TL-G3 is valid for the SOFAR 1100TL-G3, SOFAR 1600TL-G3, SOFAR 2200TL-G3, SOFAR 2700TL-G3 and SOFAR 3000TL-G3 since it is same as in hardware and just power derated by software. |   |          |

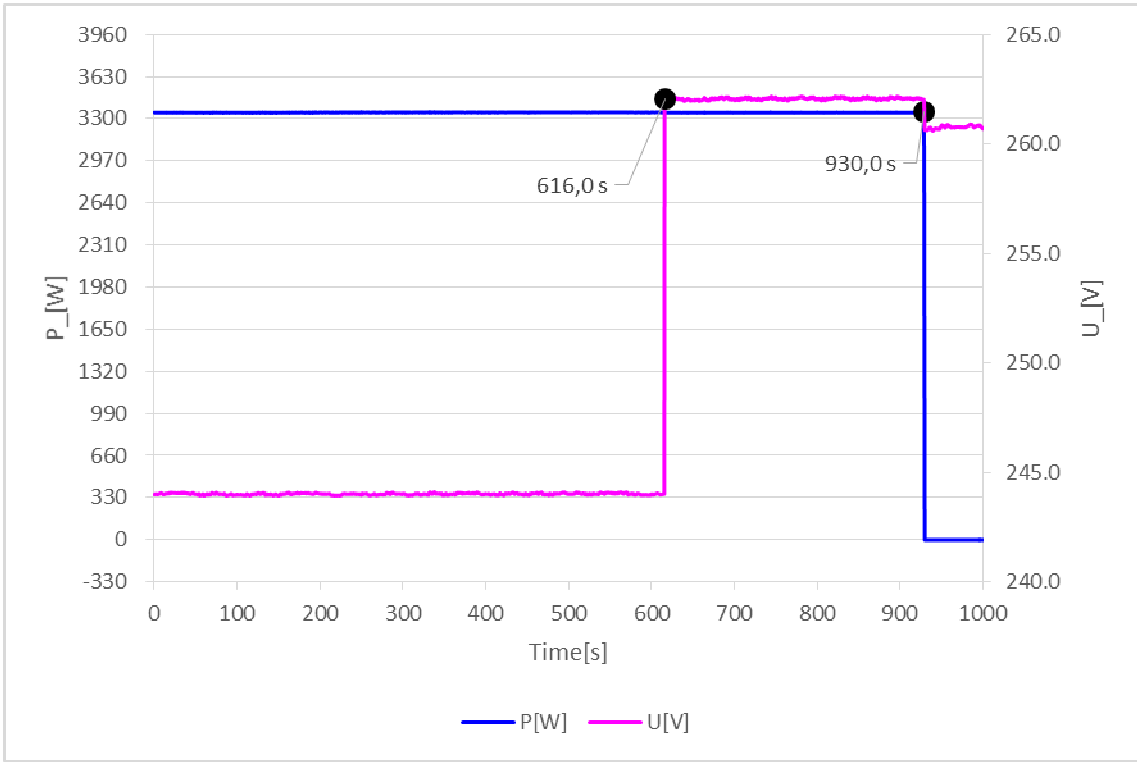
Condition a): Voltage setting  $U_n$  to 1,12 $U_n$



Condition b): Voltage setting  $U_n$  to 1,08 $U_n$



**Condition c): Voltage setting 1,06Un to 1,14Un**

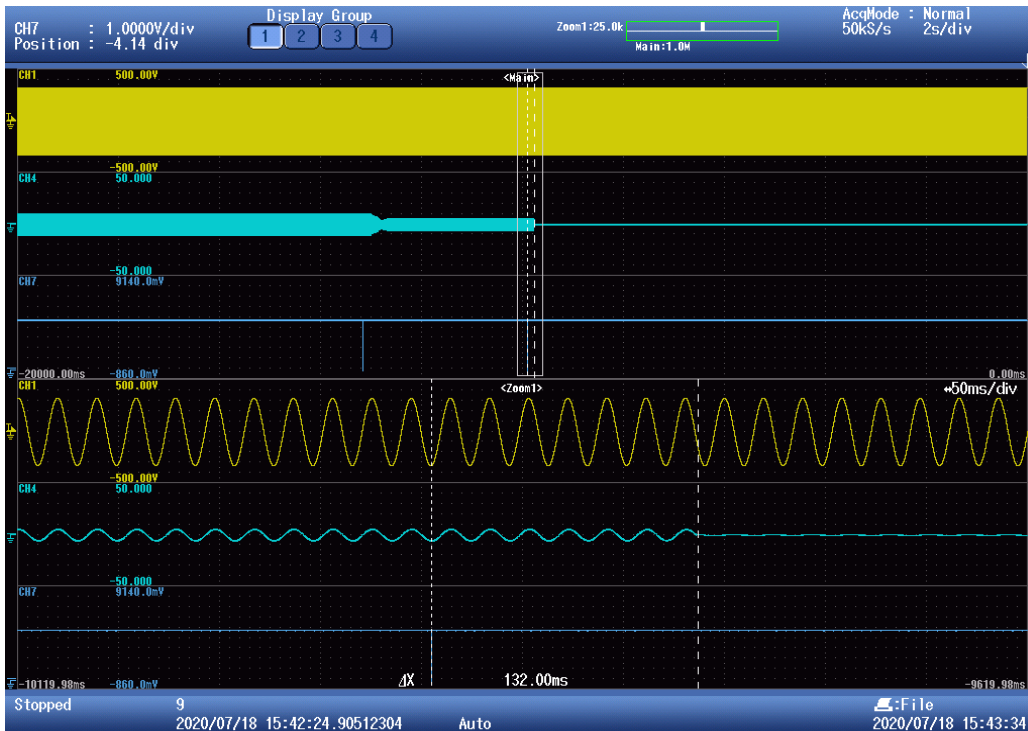


|   |  |       |            |                              |          |       |          |
|---|--|-------|------------|------------------------------|----------|-------|----------|
| <b>5.5.7.4</b>  | <b>Voltage and frequency control</b>                         |       |            |                              |          |       | <b>P</b> |
| <b>5.5.7.4.1</b>  | <b>Voltage and frequency control – Frequency measurement</b> |       |            |                              |          |       | <b>P</b> |
| Setting values of the NS protection:  | Setting  |       | Value [Hz] |                              | Time [s] |       |          |
|   | f<   |       | 47,50      |                              | 0,120    |       |          |
|   | f>   |       | 51,50      |                              | 0,120    |       |          |
| <b>Operating time of the monitoring device:</b>   |  |       |            |                              |          |       |          |
| SOFAR 3300TL-G3   |  |       |            |                              |          |       |          |
|   | <b>Under frequency (10.1):</b>                               |       |            | <b>Over frequency (8.1):</b> |          |       |          |
| Ramp [start Hz to stop Hz]  | 47,60 → 47,40  |       |            | 51,40 → 51,60                |          |       |          |
| Step size [Hz]  | <0,025   |       |            | <0,025                       |          |       |          |
| Step length [s]   | >0,4   |       |            | >0,4                         |          |       |          |
| Limit [Hz]  | 47,50 ±1% f <sub>n</sub>                                     |       |            | 51,50 ±1% f <sub>n</sub>     |          |       |          |
| Measurement [Hz]  | 47,50  | 47,50 | 47,50      | 51,52                        | 51,52    | 51,52 |          |
|   | <b>Under frequency (11.1):</b>                               |       |            | <b>Over frequency (9.1):</b> |          |       |          |
| Jump [start Hz to stop Hz]  | 47,60 → 47,40  |       |            | 51,40 → 51,60                |          |       |          |
| Step size [Hz]  | >0,2   |       |            | >0,2                         |          |       |          |
| Step length [s]   | >0,4   |       |            | >0,4                         |          |       |          |
| Limit [s]   | 0,100 ≤ t ≤ 0,200  |       |            | 0,100 ≤ t ≤ 0,200            |          |       |          |
| Disconnection time [s]  | 0,127  | 0,140 | 0,131      | 0,125                        | 0,132    | 0,122 |          |
| <b>Note:</b>  |  |       |            |                              |          |       |          |
| The setting value and the trip value of the frequency may not vary by more than ±0,1 % f <sub>n</sub> .   |  |       |            |                              |          |       |          |
| The tests had been performed on the SOFAR 3300TL-G3 is valid for the SOFAR 1100TL-G3, SOFAR 1600TL-G3, SOFAR 2200TL-G3, SOFAR 2700TL-G3 and SOFAR 3000TL-G3 since it is same as in hardware and just power derated by software. |  |       |            |                              |          |       |          |

**Under frequency:**



**Over frequency:**



| 5.5.7.5   | Reporting NS protection | P |      |                    |                   |      |      |                   |   |      |   |                    |   |      |    |                   |   |      |   |                    |   |      |    |                   |   |      |   |                    |   |      |    |                   |   |      |   |                    |   |      |    |                   |   |      |   |                    |   |      |    |                   |   |      |   |                    |   |      |    |                   |   |      |   |                    |   |      |    |                   |   |      |   |                    |   |      |    |                   |   |      |
|---|-------------------------|---|------|--------------------|-------------------|------|------|-------------------|---|------|---|--------------------|---|------|----|-------------------|---|------|---|--------------------|---|------|----|-------------------|---|------|---|--------------------|---|------|----|-------------------|---|------|---|--------------------|---|------|----|-------------------|---|------|---|--------------------|---|------|----|-------------------|---|------|---|--------------------|---|------|----|-------------------|---|------|---|--------------------|---|------|----|-------------------|---|------|---|--------------------|---|------|----|-------------------|---|------|
| <p>The last 5 dated failure reports on the NS protection can be read. An interruption in the supply voltage of <math>\leq 3s</math> does not result in any loss of failure reports.</p>   |                         |   |      |                    |                   |      |      |                   |   |      |   |                    |   |      |    |                   |   |      |   |                    |   |      |    |                   |   |      |   |                    |   |      |    |                   |   |      |   |                    |   |      |    |                   |   |      |   |                    |   |      |    |                   |   |      |   |                    |   |      |    |                   |   |      |   |                    |   |      |    |                   |   |      |   |                    |   |      |    |                   |   |      |
| <p>Central NS protection:</p>   |                         |   |      |                    |                   |      |      |                   |   |      |   |                    |   |      |    |                   |   |      |   |                    |   |      |    |                   |   |      |   |                    |   |      |    |                   |   |      |   |                    |   |      |    |                   |   |      |   |                    |   |      |    |                   |   |      |   |                    |   |      |    |                   |   |      |   |                    |   |      |    |                   |   |      |   |                    |   |      |    |                   |   |      |
| <p>It is possible to read the setting values and the failure reports of the NS protection independently of the operational state and without any additional aids.</p>   |                         |   |      |                    |                   |      |      |                   |   |      |   |                    |   |      |    |                   |   |      |   |                    |   |      |    |                   |   |      |   |                    |   |      |    |                   |   |      |   |                    |   |      |    |                   |   |      |   |                    |   |      |    |                   |   |      |   |                    |   |      |    |                   |   |      |   |                    |   |      |    |                   |   |      |   |                    |   |      |    |                   |   |      |
| <p>Integrated NS protection:</p>  |                         |   |      |                    |                   |      |      |                   |   |      |   |                    |   |      |    |                   |   |      |   |                    |   |      |    |                   |   |      |   |                    |   |      |    |                   |   |      |   |                    |   |      |    |                   |   |      |   |                    |   |      |    |                   |   |      |   |                    |   |      |    |                   |   |      |   |                    |   |      |    |                   |   |      |   |                    |   |      |    |                   |   |      |
| <p>It is possible to read out the values of the NS protection via the data interface, if the values are not directly readable.</p>  |                         |   |      |                    |                   |      |      |                   |   |      |   |                    |   |      |    |                   |   |      |   |                    |   |      |    |                   |   |      |   |                    |   |      |    |                   |   |      |   |                    |   |      |    |                   |   |      |   |                    |   |      |    |                   |   |      |   |                    |   |      |    |                   |   |      |   |                    |   |      |    |                   |   |      |   |                    |   |      |    |                   |   |      |
| <p><b>Picture of 5 last dated failure:</b></p>  |                         |   |      |                    |                   |      |      |                   |   |      |   |                    |   |      |    |                   |   |      |   |                    |   |      |    |                   |   |      |   |                    |   |      |    |                   |   |      |   |                    |   |      |    |                   |   |      |   |                    |   |      |    |                   |   |      |   |                    |   |      |    |                   |   |      |   |                    |   |      |    |                   |   |      |   |                    |   |      |    |                   |   |      |
| <table border="1"> <tbody> <tr> <td>1</td> <td>2020-3-20 14:18:46</td> <td>2</td> <td>电网欠压</td> <td>51</td> <td>2020-3-5 22:11:58</td> <td>2</td> <td>电网欠压</td> </tr> <tr> <td>2</td> <td>2020-3-20 14:18:41</td> <td>4</td> <td>电网欠频</td> <td>52</td> <td>2020-3-5 20:58:26</td> <td>4</td> <td>电网欠频</td> </tr> <tr> <td>3</td> <td>2020-3-20 14:07:13</td> <td>4</td> <td>电网欠频</td> <td>53</td> <td>2020-3-5 20:58:26</td> <td>2</td> <td>电网欠压</td> </tr> <tr> <td>4</td> <td>2020-3-20 14:07:13</td> <td>2</td> <td>电网欠压</td> <td>54</td> <td>2020-3-5 15:53:31</td> <td>4</td> <td>电网欠频</td> </tr> <tr> <td>5</td> <td>2020-3-14 20:43:32</td> <td>4</td> <td>电网欠频</td> <td>55</td> <td>2020-3-5 15:53:31</td> <td>2</td> <td>电网欠压</td> </tr> <tr> <td>6</td> <td>2020-3-14 20:43:32</td> <td>2</td> <td>电网欠压</td> <td>56</td> <td>2020-3-4 21:44:28</td> <td>4</td> <td>电网欠频</td> </tr> <tr> <td>7</td> <td>2020-3-14 17:42:32</td> <td>1</td> <td>电网过压</td> <td>57</td> <td>2020-3-4 21:44:28</td> <td>2</td> <td>电网欠压</td> </tr> <tr> <td>8</td> <td>2020-3-14 17:42:26</td> <td>4</td> <td>电网欠频</td> <td>58</td> <td>2020-3-4 18:55:58</td> <td>4</td> <td>电网欠频</td> </tr> <tr> <td>9</td> <td>2020-3-14 17:42:25</td> <td>3</td> <td>电网过频</td> <td>59</td> <td>2020-3-4 18:55:58</td> <td>2</td> <td>电网欠压</td> </tr> </tbody> </table> |                         |   | 1    | 2020-3-20 14:18:46 | 2                 | 电网欠压 | 51   | 2020-3-5 22:11:58 | 2 | 电网欠压 | 2 | 2020-3-20 14:18:41 | 4 | 电网欠频 | 52 | 2020-3-5 20:58:26 | 4 | 电网欠频 | 3 | 2020-3-20 14:07:13 | 4 | 电网欠频 | 53 | 2020-3-5 20:58:26 | 2 | 电网欠压 | 4 | 2020-3-20 14:07:13 | 2 | 电网欠压 | 54 | 2020-3-5 15:53:31 | 4 | 电网欠频 | 5 | 2020-3-14 20:43:32 | 4 | 电网欠频 | 55 | 2020-3-5 15:53:31 | 2 | 电网欠压 | 6 | 2020-3-14 20:43:32 | 2 | 电网欠压 | 56 | 2020-3-4 21:44:28 | 4 | 电网欠频 | 7 | 2020-3-14 17:42:32 | 1 | 电网过压 | 57 | 2020-3-4 21:44:28 | 2 | 电网欠压 | 8 | 2020-3-14 17:42:26 | 4 | 电网欠频 | 58 | 2020-3-4 18:55:58 | 4 | 电网欠频 | 9 | 2020-3-14 17:42:25 | 3 | 电网过频 | 59 | 2020-3-4 18:55:58 | 2 | 电网欠压 |
| 1   | 2020-3-20 14:18:46      | 2 | 电网欠压 | 51                 | 2020-3-5 22:11:58 | 2    | 电网欠压 |                   |   |      |   |                    |   |      |    |                   |   |      |   |                    |   |      |    |                   |   |      |   |                    |   |      |    |                   |   |      |   |                    |   |      |    |                   |   |      |   |                    |   |      |    |                   |   |      |   |                    |   |      |    |                   |   |      |   |                    |   |      |    |                   |   |      |   |                    |   |      |    |                   |   |      |
| 2   | 2020-3-20 14:18:41      | 4 | 电网欠频 | 52                 | 2020-3-5 20:58:26 | 4    | 电网欠频 |                   |   |      |   |                    |   |      |    |                   |   |      |   |                    |   |      |    |                   |   |      |   |                    |   |      |    |                   |   |      |   |                    |   |      |    |                   |   |      |   |                    |   |      |    |                   |   |      |   |                    |   |      |    |                   |   |      |   |                    |   |      |    |                   |   |      |   |                    |   |      |    |                   |   |      |
| 3   | 2020-3-20 14:07:13      | 4 | 电网欠频 | 53                 | 2020-3-5 20:58:26 | 2    | 电网欠压 |                   |   |      |   |                    |   |      |    |                   |   |      |   |                    |   |      |    |                   |   |      |   |                    |   |      |    |                   |   |      |   |                    |   |      |    |                   |   |      |   |                    |   |      |    |                   |   |      |   |                    |   |      |    |                   |   |      |   |                    |   |      |    |                   |   |      |   |                    |   |      |    |                   |   |      |
| 4   | 2020-3-20 14:07:13      | 2 | 电网欠压 | 54                 | 2020-3-5 15:53:31 | 4    | 电网欠频 |                   |   |      |   |                    |   |      |    |                   |   |      |   |                    |   |      |    |                   |   |      |   |                    |   |      |    |                   |   |      |   |                    |   |      |    |                   |   |      |   |                    |   |      |    |                   |   |      |   |                    |   |      |    |                   |   |      |   |                    |   |      |    |                   |   |      |   |                    |   |      |    |                   |   |      |
| 5   | 2020-3-14 20:43:32      | 4 | 电网欠频 | 55                 | 2020-3-5 15:53:31 | 2    | 电网欠压 |                   |   |      |   |                    |   |      |    |                   |   |      |   |                    |   |      |    |                   |   |      |   |                    |   |      |    |                   |   |      |   |                    |   |      |    |                   |   |      |   |                    |   |      |    |                   |   |      |   |                    |   |      |    |                   |   |      |   |                    |   |      |    |                   |   |      |   |                    |   |      |    |                   |   |      |
| 6   | 2020-3-14 20:43:32      | 2 | 电网欠压 | 56                 | 2020-3-4 21:44:28 | 4    | 电网欠频 |                   |   |      |   |                    |   |      |    |                   |   |      |   |                    |   |      |    |                   |   |      |   |                    |   |      |    |                   |   |      |   |                    |   |      |    |                   |   |      |   |                    |   |      |    |                   |   |      |   |                    |   |      |    |                   |   |      |   |                    |   |      |    |                   |   |      |   |                    |   |      |    |                   |   |      |
| 7   | 2020-3-14 17:42:32      | 1 | 电网过压 | 57                 | 2020-3-4 21:44:28 | 2    | 电网欠压 |                   |   |      |   |                    |   |      |    |                   |   |      |   |                    |   |      |    |                   |   |      |   |                    |   |      |    |                   |   |      |   |                    |   |      |    |                   |   |      |   |                    |   |      |    |                   |   |      |   |                    |   |      |    |                   |   |      |   |                    |   |      |    |                   |   |      |   |                    |   |      |    |                   |   |      |
| 8   | 2020-3-14 17:42:26      | 4 | 电网欠频 | 58                 | 2020-3-4 18:55:58 | 4    | 电网欠频 |                   |   |      |   |                    |   |      |    |                   |   |      |   |                    |   |      |    |                   |   |      |   |                    |   |      |    |                   |   |      |   |                    |   |      |    |                   |   |      |   |                    |   |      |    |                   |   |      |   |                    |   |      |    |                   |   |      |   |                    |   |      |    |                   |   |      |   |                    |   |      |    |                   |   |      |
| 9   | 2020-3-14 17:42:25      | 3 | 电网过频 | 59                 | 2020-3-4 18:55:58 | 2    | 电网欠压 |                   |   |      |   |                    |   |      |    |                   |   |      |   |                    |   |      |    |                   |   |      |   |                    |   |      |    |                   |   |      |   |                    |   |      |    |                   |   |      |   |                    |   |      |    |                   |   |      |   |                    |   |      |    |                   |   |      |   |                    |   |      |    |                   |   |      |   |                    |   |      |    |                   |   |      |
| <p><b>Assessment criterion:</b></p>   |                         |   |      |                    |                   |      |      |                   |   |      |   |                    |   |      |    |                   |   |      |   |                    |   |      |    |                   |   |      |   |                    |   |      |    |                   |   |      |   |                    |   |      |    |                   |   |      |   |                    |   |      |    |                   |   |      |   |                    |   |      |    |                   |   |      |   |                    |   |      |    |                   |   |      |   |                    |   |      |    |                   |   |      |
| <p>At least the last 5 error messages including time stamps that were recorded before the voltage interruption and at least 5 error messages including time stamps that were recorded after the voltage interruption must be documented.</p>  |                         |   |      |                    |                   |      |      |                   |   |      |   |                    |   |      |    |                   |   |      |   |                    |   |      |    |                   |   |      |   |                    |   |      |    |                   |   |      |   |                    |   |      |    |                   |   |      |   |                    |   |      |    |                   |   |      |   |                    |   |      |    |                   |   |      |   |                    |   |      |    |                   |   |      |   |                    |   |      |    |                   |   |      |

|   |  |          |
|---|--|----------|
| <b>5.5.9</b>  | <b>Constructional characteristics of NS protection</b> | <b>P</b> |
| <b>5.5.9.1</b>  | <b>General</b>   | <b>P</b> |
| These tests serve to demonstrate the requirements of VDE-AR-N 4105: 2018-11, 6.5.2.   |  |          |
| <b>5.5.9.2</b>  | <b>Test</b>  | <b>P</b> |
| Type of NS protection: Internal   |  |          |
| NS-protection is sealed or a password protection is used (or both)  |  | P        |
| adjustability of U> and the time delays for U< and U<< is given   |  | P        |
| All other protective functions are either permanently protected or protected from unauthorized access by additional, separate protection (example password) |  | P        |



|  |                            |          |
|--|----------------------------|----------|
| <b>5.5.10</b>  | <b>Islanding detection</b> | <b>P</b> |
| <p>For power generation systems, islanding detection must be carried out using one of the following processes:</p> <ul style="list-style-type: none"> <li>a) active method, e.g. by means of frequency – shift process (oscillating circuit)</li> <li>b) Passive method by means of the three-phase voltage monitoring (possible only for power generation systems without inverters or for single-phase power generation units with inverters).</li> </ul> <p>(see 5.4.5.3 3-phase voltage control)</p> <p>With the passive process, it is important to provide evidence that the power generation unit can be set not equal to 120°.</p> |                            |          |
| <b>5.5.10.1</b>  | <b>General</b>             | <b>P</b> |
| <p>These tests serve as proof of the requirements of VDE-AR-N 4105: 2018-11, 6.5.3. The maximum switch-off time is 9 s.</p>  |                            |          |

| 5.5.10.3                  |   | Islanding protection according table 6 - Load imbalance (real, reactive load) for test condition A (PGU output = 100%) |   |   |                                      |    |    |                                   |                        |                       |                    | P                          |
|---------------------------|---|--|---|---|--------------------------------------|----|----|-----------------------------------|------------------------|-----------------------|--------------------|----------------------------|
| Test conditions           |   | Frequency: $50 \pm 1\% f_n$<br>$U_n = 230 \pm 1\% U_n$<br>Distortion factor of chokes $\leq 2\%$                       |   |   |                                      |    |    |                                   |                        |                       |                    |                            |
| Disconnection limit       |   | 2s (IEC 62116)   |   |   |                                      |    |    |                                   |                        |                       |                    |                            |
| SOFAR 3300TL-G3           |   |  |   |   |                                      |    |    |                                   |                        |                       |                    |                            |
| No                        | P <sub>PGU</sub> <sup>1)</sup><br>[% of PGU rating] | Reactive load<br>[% of Q <sub>L</sub> in 6.1.d) 1]   | P <sub>AC</sub> <sup>2)</sup><br>[% of nominal] | Q <sub>AC</sub> <sup>3)</sup><br>[% of nominal] | I <sub>AC</sub> <sup>4)</sup><br>[A] |    |    | P <sub>PGU</sub><br>[W per phase] | V <sub>DC</sub><br>[V] | Q <sub>f</sub><br>[1] | Run on Time<br>[s] | Re-<br>marks <sup>5)</sup> |
|                           |   |  |   |   | L1                                   | L2 | L3 |                                   |                        |                       |                    |                            |
| 1                         | 100   | 100  | 0   | 0   | 0,068                                | -- | -- | 3300                              | 343                    | 1,000                 | 456                | BL                         |
| 8                         | 100   | 100  | -5  | -5  | 0,813                                | -- | -- | 3300                              | 343                    | 1,026                 | 348                | IB                         |
| 9                         | 100   | 100  | -5  | 0   | 0,831                                | -- | -- | 3300                              | 343                    | 1,052                 | 422                | IB                         |
| 10                        | 100   | 100  | -5  | +5  | 0,812                                | -- | -- | 3300                              | 343                    | 1,078                 | 454                | IB                         |
| 13                        | 100   | 100  | 0   | -5  | 0,094                                | -- | -- | 3300                              | 343                    | 0,974                 | 404                | IB                         |
| 14                        | 100   | 100  | 0   | +5  | 0,093                                | -- | -- | 3300                              | 343                    | 1,024                 | 444                | IB                         |
| 17                        | 100   | 100  | +5  | -5  | 0,761                                | -- | -- | 3300                              | 343                    | 0,928                 | 368                | IB                         |
| 18                        | 100   | 100  | +5  | 0   | 0,744                                | -- | -- | 3300                              | 343                    | 0,952                 | 434                | IB                         |
| 19                        | 100   | 100  | +5  | +5  | 0,762                                | -- | -- | 3300                              | 343                    | 0,976                 | 328                | IB                         |
| Parameter at 0% per phase |   | L= 50,90 mH  |   |   | R= 15,98 Ω                           |    |    | C= 199,17 μF                      |                        |                       |                    |                            |

|                 |   |          |
|-----------------|---|----------|
| <b>5.5.10.3</b> | <b>Islanding protection according table 6 - Load imbalance (real, reactive load) for test condition A (PGU output = 100%)</b> | <b>P</b> |
|-----------------|---|----------|

**Note:**

RLC is adjusted to min. +/-1% of the inverter rated output power

- 1)  $P_{PGU}$ : PGU output power
  - 2)  $P_{AC}$ : Real power flow at S1 in Figure 1. Positive means power from PGU to utility. Nominal is the 0 % test condition value.
  - 3)  $Q_{AC}$ : Reactive power flow at S1 in Figure 1. Positive means power from PGU to utility. Nominal is the 0 % test condition value.
  - 4) Fundamental of  $I_{AC}$  when RLC is adjusted
  - 5) BL: Balance condition, IB: Imbalance condition.
- Condition A:  
 PGU output power  $P_{PGU} = \text{Maximum}$  <sup>6)</sup>  
 PGU input voltage <sup>6)</sup>  $\geq 75\%$  of rated input voltage range  
<sup>6)</sup> Maximum PGU output power condition should be achieved using the maximum allowable input power. Actual output power may exceed nominal rated output.  
<sup>7)</sup> Based on PGU rated input operating range. For example, If range is between X volts and Y volts, 75 % of range =  $X + 0,75 \times (Y - X)$ . Y shall not exceed  $0,8 \times$  PGU maximum system voltage (i.e., maximum allowable array open circuit voltage). In any case, the PGU should not be operated outside of its allowable input voltage range.

The tests had been performed on the SOFAR 3300TL-G3 is valid for the SOFAR 1100TL-G3, SOFAR 1600TL-G3, SOFAR 2200TL-G3, SOFAR 2700TL-G3 and SOFAR 3000TL-G3 since it is same as in hardware and just power derated by software.

**Scope pictures of the disconnection time**

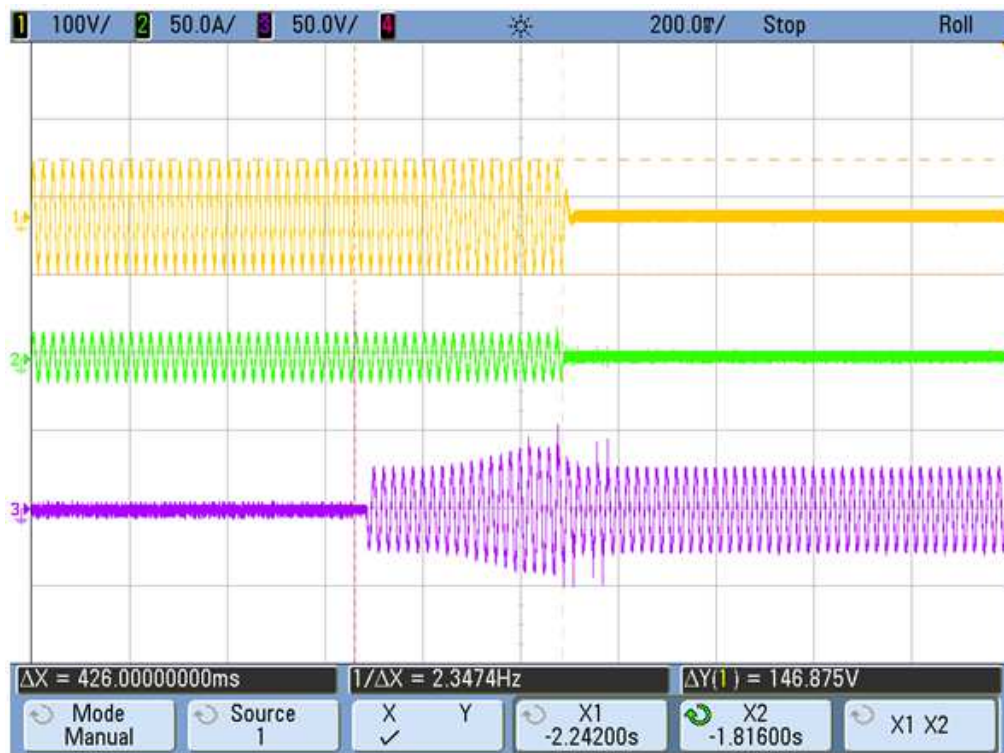
Disconnection at No. 1



| 5.5.10.3  |   | Islanding protection according Table 7 – Load imbalance (reactive load) for test condition B (PGU output = 50 % – 66 %) |   |   |                                      |    |    |                                   |                        |                       |                    | P                          |
|---|---|---|---|---|--------------------------------------|----|----|-----------------------------------|------------------------|-----------------------|--------------------|----------------------------|
| Test conditions   |   | Frequency: $50 \pm 1\% f_n$<br>$U_n = 230 \pm 1\% U_n$<br>Distortion factor of chokes $\leq 2\%$                        |   |   |                                      |    |    |                                   |                        |                       |                    |                            |
| Disconnection limit   |   | 2s (IEC 62116)  |   |   |                                      |    |    |                                   |                        |                       |                    |                            |
| No  | P <sub>PGU</sub> <sup>1)</sup><br>[% of PGU rating] | Reactive load<br>[% of Q <sub>L</sub> in 6.1.d) 1]  | P <sub>AC</sub> <sup>2)</sup><br>[% of nominal] | Q <sub>AC</sub> <sup>3)</sup><br>[% of nominal] | I <sub>AC</sub> <sup>4)</sup><br>[A] |    |    | P <sub>PGU</sub><br>[W per phase] | V <sub>DC</sub><br>[V] | Q <sub>f</sub><br>[1] | Run on Time<br>[s] | Re-<br>marks <sup>5)</sup> |
|   |   |   |   |   | L1                                   | L2 | L3 |                                   |                        |                       |                    |                            |
| 12  | 66  | 66  | 0   | -5  | 0,077                                | -- | -- | 2,178                             | 245                    | 0,976                 | 340                | BL                         |
| 13  | 66  | 66  | 0   | -4  | 0,081                                | -- | -- | 2,178                             | 245                    | 0,981                 | 328                | IB                         |
| 14  | 66  | 66  | 0   | -3  | 0,085                                | -- | -- | 2,178                             | 245                    | 0,986                 | 336                | IB                         |
| 15  | 66  | 66  | 0   | -2  | 0,087                                | -- | -- | 2,178                             | 245                    | 0,991                 | 344                | IB                         |
| 16  | 66  | 66  | 0   | -1  | 0,089                                | -- | -- | 2,178                             | 245                    | 0,996                 | 314                | IB                         |
| 2   | 66  | 66  | 0   | 0   | 0,076                                | -- | -- | 2,178                             | 245                    | 1,001                 | 412                | IB                         |
| 17  | 66  | 66  | 0   | 1   | 0,089                                | -- | -- | 2,178                             | 245                    | 1,006                 | 364                | IB                         |
| 18  | 66  | 66  | 0   | 2   | 0,087                                | -- | -- | 2,178                             | 245                    | 1,011                 | 410                | IB                         |
| 19  | 66  | 66  | 0   | 3   | 0,085                                | -- | -- | 2,178                             | 245                    | 1,016                 | 426                | IB                         |
| 20  | 66  | 66  | 0   | 4   | 0,081                                | -- | -- | 2,178                             | 245                    | 1,021                 | 350                | IB                         |
| 21  | 66  | 66  | 0   | 5   | 0,077                                | -- | -- | 2,178                             | 245                    | 1,026                 | 316                | IB                         |
| Parameter at 0% per phase   |   | L= 77,34 mH   |   |   | R= 24,32 Ω                           |    |    | C= 131,00 μF                      |                        |                       |                    |                            |
| <b>Note:</b>  |   |   |   |   |                                      |    |    |                                   |                        |                       |                    |                            |
| RLC is adjusted to min. +/-1% of the inverter rated output power  |   |   |   |   |                                      |    |    |                                   |                        |                       |                    |                            |
| 1) P <sub>PGU</sub> : PGU output power  |   |   |   |   |                                      |    |    |                                   |                        |                       |                    |                            |
| 2) P <sub>AC</sub> : Real power flow at S1 in Figure 1. Positive means power from PGU to utility. Nominal is the 0 % test condition value.  |   |   |   |   |                                      |    |    |                                   |                        |                       |                    |                            |
| 3) Q <sub>AC</sub> : Reactive power flow at S1 in Figure 1. Positive means power from PGU to utility. Nominal is the 0 % test condition value.  |   |   |   |   |                                      |    |    |                                   |                        |                       |                    |                            |
| 4) Fundamental of I <sub>AC</sub> when RLC is adjusted  |   |   |   |   |                                      |    |    |                                   |                        |                       |                    |                            |
| 5) BL: Balance condition, IB: Imbalance condition.  |   |   |   |   |                                      |    |    |                                   |                        |                       |                    |                            |
| Condition B:  |   |   |   |   |                                      |    |    |                                   |                        |                       |                    |                            |
| PGU output power P <sub>PGU</sub> = 50 % – 66 % of maximum  |   |   |   |   |                                      |    |    |                                   |                        |                       |                    |                            |
| PGU input voltage <sup>6)</sup> = 50 % of rated input voltage range, ±10 %  |   |   |   |   |                                      |    |    |                                   |                        |                       |                    |                            |
| 6) Based on PGU rated input operating range. For example, If range is between X volts and Y volts, 50 % of range = X + 0,5 × (Y – X). Y shall not exceed 0,8 × PGU maximum system voltage (i.e., maximum allowable array open circuit voltage). In any case, the PGU should not be operated outside of its allowable input voltage range. |   |   |   |   |                                      |    |    |                                   |                        |                       |                    |                            |
| The tests had been performed on the SOFAR 3300TL-G3 is valid for the SOFAR 1100TL-G3, SOFAR 1600TL-G3, SOFAR 2200TL-G3, SOFAR 2700TL-G3 and SOFAR 3000TL-G3 since it is same as in hardware and just power derated by software.   |   |   |   |   |                                      |    |    |                                   |                        |                       |                    |                            |

Scope pictures of the disconnection time

Disconnection at No. 19



| 5.5.10   |   | Islanding protection according Table 7 – Load imbalance (reactive load) for test condition B (PGU output = 25 % – 33 %) |  |   |                                      |            |    |                                   |                        |                       |                    | P                          |
|--|---|---|--|---|--------------------------------------|------------|----|-----------------------------------|------------------------|-----------------------|--------------------|----------------------------|
| Test conditions  |   |   | Frequency: $50 \pm 1\% f_n$<br>$U_n = 230 \pm 1\% U_n$<br>Distortion factor of chokes $\leq 2\%$ |   |                                      |            |    |                                   |                        |                       |                    |                            |
| Disconnection limit  |   |   | 2s (IEC 62116)   |   |                                      |            |    |                                   |                        |                       |                    |                            |
| No   | P <sub>PGU</sub> <sup>1)</sup><br>[% of PGU rating] | Reactive load<br>[% of Q <sub>L</sub> in 6.1.d) 1]  | P <sub>AC</sub> <sup>2)</sup><br>[% of nominal]  | Q <sub>AC</sub> <sup>3)</sup><br>[% of nominal] | I <sub>AC</sub> <sup>4)</sup><br>[A] |            |    | P <sub>PGU</sub><br>[W per phase] | V <sub>DC</sub><br>[V] | Q <sub>f</sub><br>[1] | Run on Time<br>[s] | Re-<br>marks <sup>5)</sup> |
|  |   |   |  |   | L1                                   | L2         | L3 |                                   |                        |                       |                    |                            |
| 22   | 33  | 33  | 0  | -5  | 0,62                                 | --         | -- | 1089                              | 128                    | 0,975                 | 296                | BL                         |
| 23   | 33  | 33  | 0  | -4  | 0,62                                 | --         | -- | 1089                              | 128                    | 0,980                 | 350                | IB                         |
| 24   | 33  | 33  | 0  | -3  | 0,61                                 | --         | -- | 1089                              | 128                    | 0,985                 | 360                | IB                         |
| 25   | 33  | 33  | 0  | -2  | 0,61                                 | --         | -- | 1089                              | 128                    | 0,990                 | 352                | IB                         |
| 26   | 33  | 33  | 0  | -1  | 0,61                                 | --         | -- | 1089                              | 128                    | 0,995                 | 388                | IB                         |
| 3  | 33  | 33  | 0  | 0   | 0,48                                 | --         | -- | 1089                              | 128                    | 1,000                 | 376                | IB                         |
| 27   | 33  | 33  | 0  | 1   | 0,61                                 | --         | -- | 1089                              | 128                    | 1,005                 | 396                | IB                         |
| 28   | 33  | 33  | 0  | 2   | 0,61                                 | --         | -- | 1089                              | 128                    | 1,010                 | 416                | IB                         |
| 29   | 33  | 33  | 0  | 3   | 0,61                                 | --         | -- | 1089                              | 128                    | 1,015                 | 382                | IB                         |
| 30   | 33  | 33  | 0  | 4   | 0,61                                 | --         | -- | 1089                              | 128                    | 1,020                 | 380                | IB                         |
| 31   | 33  | 33  | 0  | 5   | 0,61                                 | --         | -- | 1089                              | 128                    | 1,025                 | 318                | IB                         |
| Parameter at 0% per phase  |   |   | L= 150,61 mH   |   |                                      | R= 47,32 Ω |    |                                   | C= 67,27 μF            |                       |                    |                            |
| <b>Note:</b>   |   |   |  |   |                                      |            |    |                                   |                        |                       |                    |                            |
| RLC is adjusted to min. +/-1% of the inverter rated output power   |   |   |  |   |                                      |            |    |                                   |                        |                       |                    |                            |
| 1) P <sub>PGU</sub> : PGU output power   |   |   |  |   |                                      |            |    |                                   |                        |                       |                    |                            |
| 2) P <sub>AC</sub> : Real power flow at S1 in Figure 1. Positive means power from PGU to utility. Nominal is the 0 % test condition value.   |   |   |  |   |                                      |            |    |                                   |                        |                       |                    |                            |
| 3) Q <sub>AC</sub> : Reactive power flow at S1 in Figure 1. Positive means power from PGU to utility. Nominal is the 0 % test condition value.   |   |   |  |   |                                      |            |    |                                   |                        |                       |                    |                            |
| 4) Fundamental of I <sub>AC</sub> when RLC is adjusted   |   |   |  |   |                                      |            |    |                                   |                        |                       |                    |                            |
| 5) BL: Balance condition, IB: Imbalance condition.   |   |   |  |   |                                      |            |    |                                   |                        |                       |                    |                            |
| Condition B:   |   |   |  |   |                                      |            |    |                                   |                        |                       |                    |                            |
| PGU output power P <sub>PGU</sub> = 25 % – 33 % <sup>6)</sup> of maximum   |   |   |  |   |                                      |            |    |                                   |                        |                       |                    |                            |
| PGU input voltage <sup>7)</sup> < 20 % of rated input voltage range  |   |   |  |   |                                      |            |    |                                   |                        |                       |                    |                            |
| <sup>6)</sup> Or minimum allowable PGU output level if greater than 33 %.  |   |   |  |   |                                      |            |    |                                   |                        |                       |                    |                            |
| <sup>7)</sup> Based on PGU rated input operating range. For example, If range is between X volts and Y volts, 20 % of range = X + 0,2 × (Y – X). Y shall not exceed 0,8 × PGU maximum system voltage (i.e., maximum allowable array open circuit voltage). In any case, the PGU should not be operated outside of its allowable input voltage range. |   |   |  |   |                                      |            |    |                                   |                        |                       |                    |                            |
| The tests had been performed on the SOFAR 3300TL-G3 is valid for the SOFAR 1100TL-G3, SOFAR 1600TL-G3, SOFAR 2200TL-G3, SOFAR 2700TL-G3 and SOFAR 3000TL-G3 since it is same as in hardware and just power derated by software.  |   |   |  |   |                                      |            |    |                                   |                        |                       |                    |                            |

**Scope pictures of the disconnection time**

Disconnection at No. 28

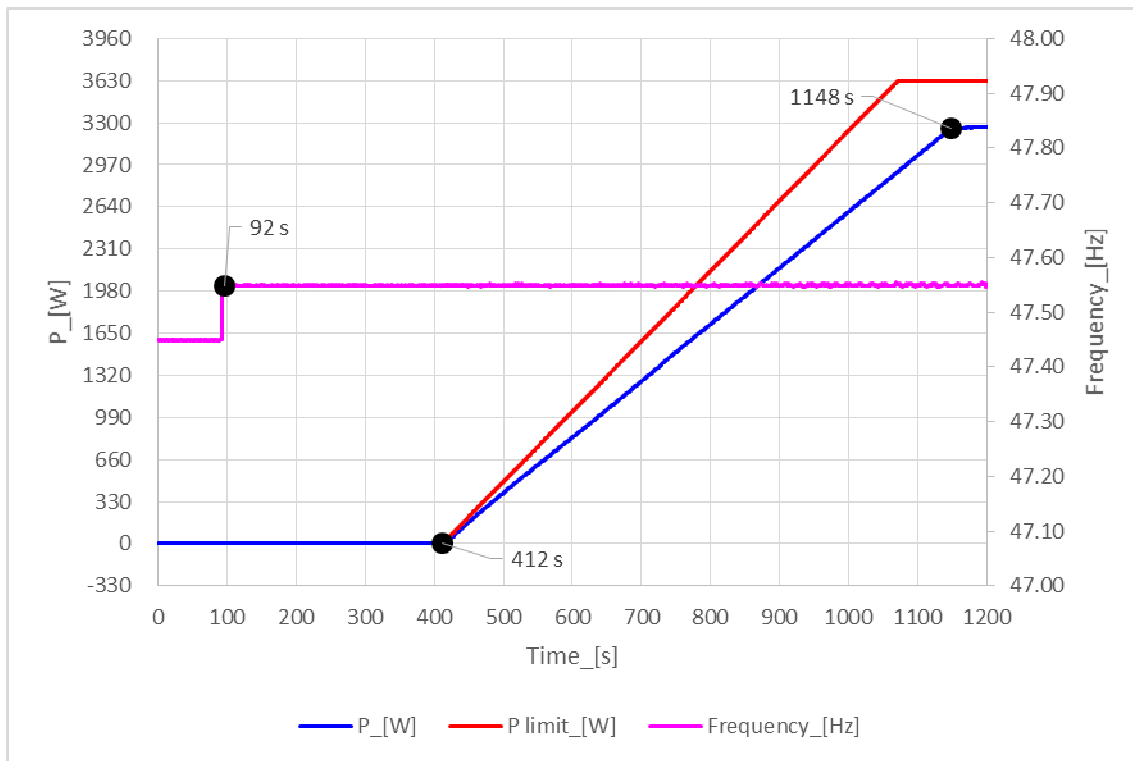


| <b>5.6 Testing of connecting conditions and synchronisation</b> |   |                |
|---|---|----------------|
| <b>Clause</b>   | <b>Requirement – Test</b>                 | <b>Verdict</b> |
| <b>5.6.1</b>  | General                                   | <b>P</b>       |
| <b>5.6.2</b>  | Connecting conditions and synchronisation | <b>P</b>       |

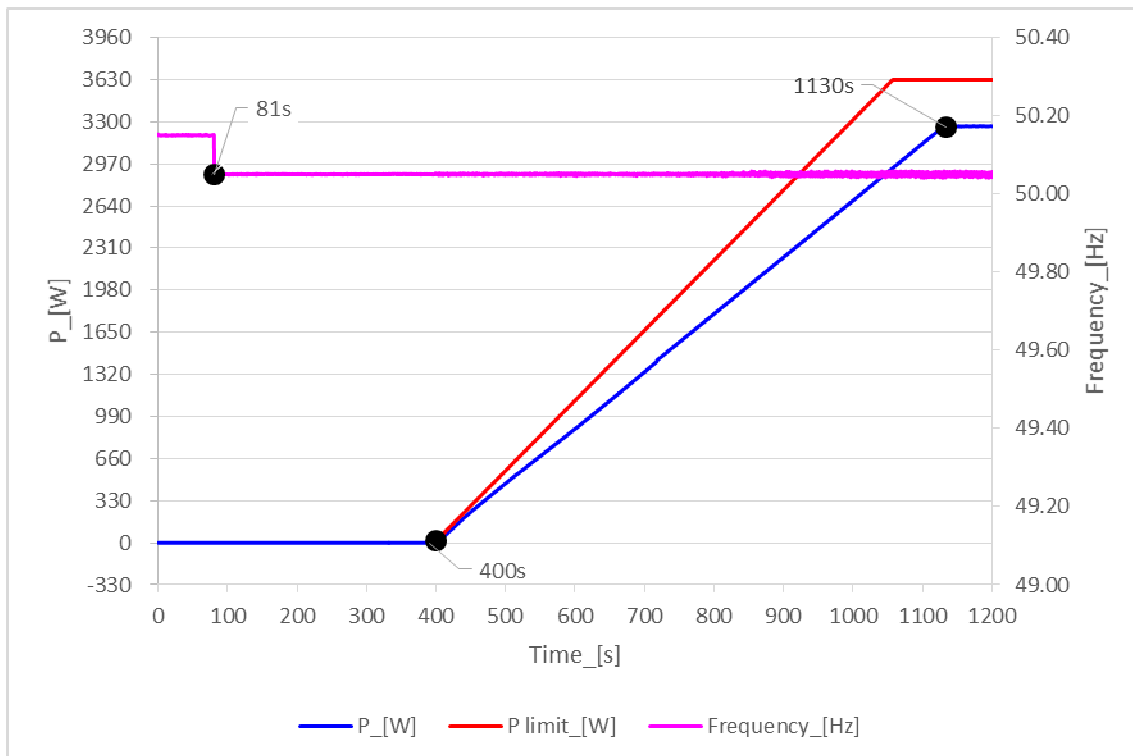


| 5.6.2.   |   | Connecting conditions and synchronisation |                      | P |
|--|---|---|----------------------|---|
| Setting values of the NS protection:   | Setting $T_{\text{reconnection 60s}}$ [s] | 300                                       |                      |   |
|  | Setting $f <$ [Hz]                        | 47,50                                     |                      |   |
|  | Setting $f >$ [Hz]                        | 50,10                                     |                      |   |
|  | Setting $V <$ [V]                         | 184,0                                     |                      |   |
|  | Setting $V >>$ [V]                        | 253                                       |                      |   |
| <b>Test:</b>   |   |   |                      |   |
|  | $f_{\text{ist}}$                          | <b>Reset time:</b>                        | <b>Limit:</b>        |   |
| <b>Connecting conditions for frequencies:</b>  |   |   |                      |   |
| a)   | 47,45Hz                                   | No reconnection                           | No resetting allowed |   |
|  | Switch to:                                |   |                      |   |
| b)   | $\geq 47,55\text{Hz}$                     | 320 s                                     | $\geq 60\text{s}$    |   |
| c)   | 50,06Hz                                   | No reconnection                           | No resetting allowed |   |
|  | Switch to:                                |   |                      |   |
| d)   | $\geq 50,0\text{Hz}$                      | 319 s                                     | $\geq 60\text{s}$    |   |
| <b>Connecting conditions for voltages:</b>   |   |   |                      |   |
| e)   | 84%                                       | No reconnection                           | No resetting allowed |   |
|  | Switch to:                                |   |                      |   |
| f)   | $\geq 86\%$                               | 319 s                                     | $\geq 60\text{s}$    |   |
| g)   | 111%                                      | No reconnection                           | No resetting allowed |   |
|  | Switch to:                                |   |                      |   |
| h)   | $\leq 109\%$                              | 319 s                                     | $\geq 60\text{s}$    |   |
| <b>Test:</b>   |   |   |                      |   |
| see points a) to h) for the test process.  |   |   |                      |   |
| The measurement was carried out with a programmable AC source.   |   |   |                      |   |
| e.g. connecting conditions for frequencies: Point a) and b). The AC source was programmed in such a way that the first step of 230V/50Hz to 200V/47,0Hz resulted in a faulty disconnection. Thereafter the voltage and frequency for 100s is set to 215V/47,45Hz. Switching on again is not permitted. After a lapse of 100s the voltage is set to 230V/47,55Hz. Setting again after 60s is permitted. |   |   |                      |   |
| The tests had been performed on the SOFAR 3300TL-G3 is valid for the SOFAR 1100TL-G3, SOFAR 1600TL-G3, SOFAR 2200TL-G3, SOFAR 2700TL-G3 and SOFAR 3000TL-G3 since it is same as in hardware and just power derated by software.  |   |   |                      |   |
| <b>Assessment criterion:</b>   |   |   |                      |   |
| After actuating the NS protection it should be checked that the system can only be switched within the tolerance ranges ( $(80\% U_n \leq U \leq 110\% U_n)$ and $(47,5\text{Hz} \leq f \leq 50,05\text{Hz})$ ) at the earliest after 60s after voltage and frequency has remained within the tolerance ranges.  |   |   |                      |   |

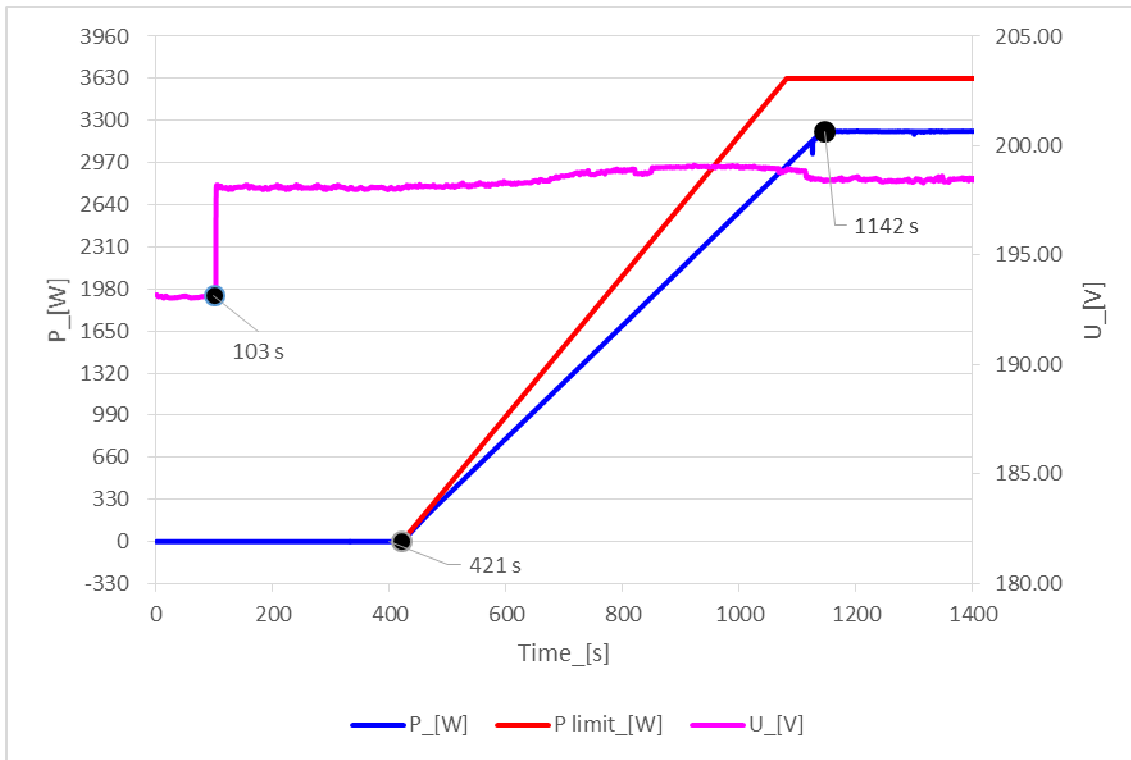
a) 47,50 Hz to b)  $\geq 47,55$  Hz:



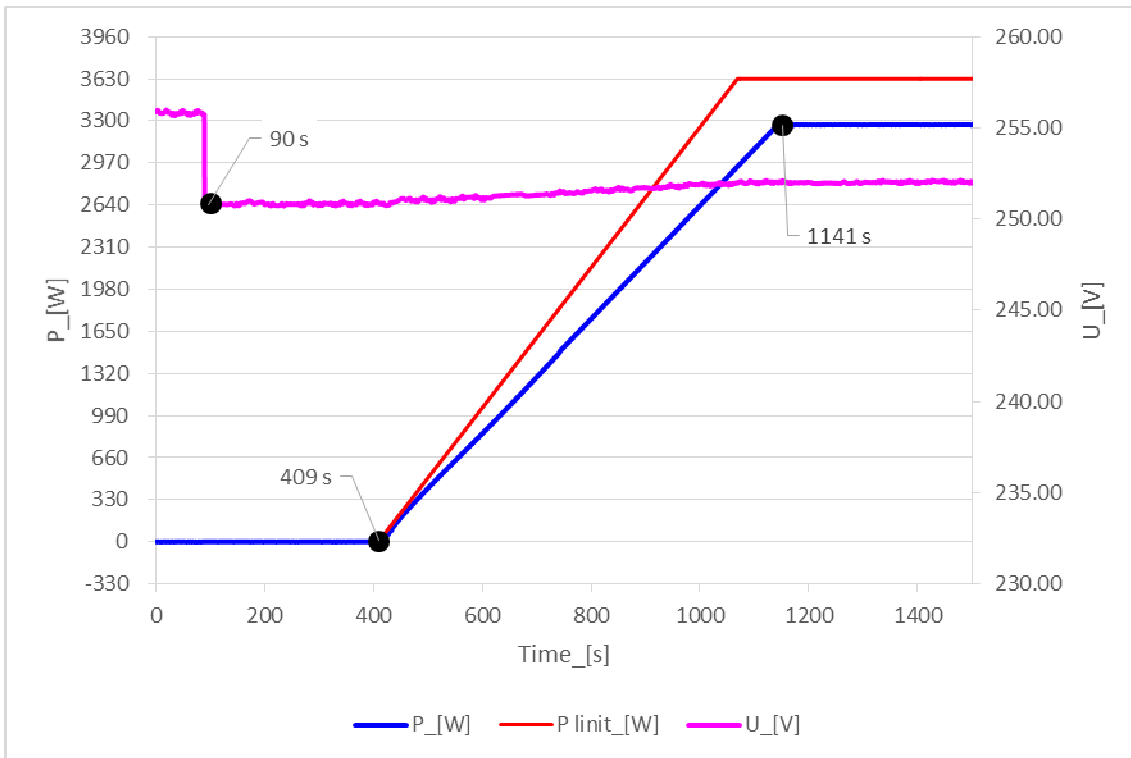
c) 50,15 Hz to d)  $\leq 50,05$  Hz:



e) 84 % Un to f) ≥ 86 % Un:



g) 111 % Un to h) ≤ 109 % Un:

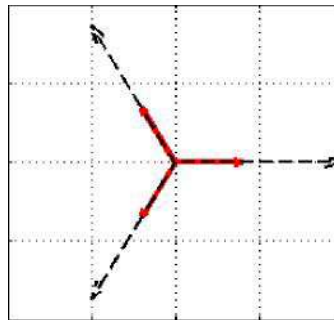


| <b>5.7 Evidence of P<sub>AV,E</sub> –Control</b> |                             |                |
|--|-----------------------------|----------------|
| <b>Clause</b>                                    | <b>Requirement – Test</b>   | <b>Verdict</b> |
| 5.7.1  | General                     | N/A            |
| 5.7.2.1  | Test control dynamic        | N/A            |
| 5.7.2.2  | Test disconnection function | N/A            |

| <b>5.8 Evidence dynamic grid support</b> |  |                |
|--|--|----------------|
| <b>Clause</b>                            | <b>Requirement – Test</b>                      | <b>Verdict</b> |
| <b>5.8.1</b>                             | General  | <b>P</b>       |
| <b>5.8.3</b>                             | Testing of the dynamic grid support PGU Type 1 | <b>N/A</b>     |
| <b>5.8.3</b>                             | Testing of the dynamic grid support PGU Type 2 | <b>P</b>       |

|       |         |          |
|-------|---------|----------|
| 5.8.1 | General | <b>P</b> |
|-------|---------|----------|

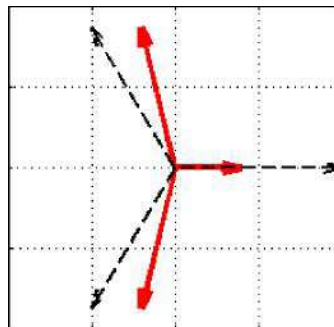
**FRT test for three-phase symmetrical (Test ref no. x.1.x)**



Typ-A

**LVRT test for two-phase asymmetrical fault (Test ref no. 1.2.x to 5.2.x)**

| Test No.         | V/V <sub>nom</sub> | Phase-to-earth voltages            |                                    |                                    | Phase angles    |                 |                 |
|------------------|--------------------|------------------------------------|------------------------------------|------------------------------------|-----------------|-----------------|-----------------|
|                  |                    | u <sub>1</sub> /u <sub>1,nom</sub> | u <sub>2</sub> /u <sub>2,nom</sub> | u <sub>3</sub> /u <sub>3,nom</sub> | φ <sub>u1</sub> | φ <sub>u2</sub> | φ <sub>u3</sub> |
| 1.2.x            | 0,1-0,15           | 0,1-0,15                           | 0,87 ± 0,05                        | 0,87 ± 0,05                        | 0°              | -94°            | 94°             |
| 2.2.x            | 0,20-0,25          | 0,20-0,25                          | 0,87 ± 0,05                        | 0,87 ± 0,05                        | 0°              | -97°            | 97°             |
| 3.2.x            | 0,50 ± 0,05        | 0,50 ± 0,05                        | 0,90 ± 0,05                        | 0,90 ± 0,05                        | 0°              | -106°           | 106°            |
| 4.2.x            | 0,75 ± 0,05        | 0,75 ± 0,05                        | 0,94 ± 0,05                        | 0,94 ± 0,05                        | 0°              | -113°           | 113°            |
| 5.2.x            | 0,92 ± 0,05        | 0,92 ± 0,05                        | 0,98 ± 0,05                        | 0,98 ± 0,05                        | 0°              | -118°           | 118°            |
| Normal condition | 1                  | 1                                  | 1                                  | 1                                  | 0°              | -120°           | 120°            |



Typ-D

**FRT test for two-phase asymmetrical fault (Test ref no. 6.2.x to 7.2.x)**

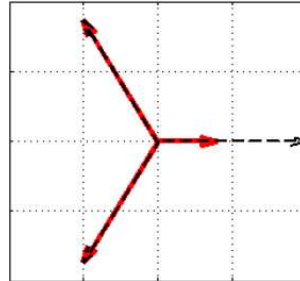
| Test No.         | V/V <sub>nom</sub> | Phase-to-earth voltages            |                                    |                                    | Phase angles    |                 |                 |
|------------------|--------------------|------------------------------------|------------------------------------|------------------------------------|-----------------|-----------------|-----------------|
|                  |                    | u <sub>1</sub> /u <sub>1,nom</sub> | u <sub>2</sub> /u <sub>2,nom</sub> | u <sub>3</sub> /u <sub>3,nom</sub> | φ <sub>u1</sub> | φ <sub>u2</sub> | φ <sub>u3</sub> |
| 6.2.x            | 1,25-1,30          | 1,25-1,30                          | 1,25-1,30                          | 1,00 ± 0,05                        | 0°              | -120°           | 120°            |
| 7.2.x            | 1,20 ± 0,05        | 1,20 ± 0,05                        | 1,20 ± 0,05                        | 1,00 ± 0,05                        | 0°              | -120°           | 120°            |
| Normal condition | 1                  | 1                                  | 1                                  | 1                                  | 0°              | -120°           | 120°            |

5.8.1

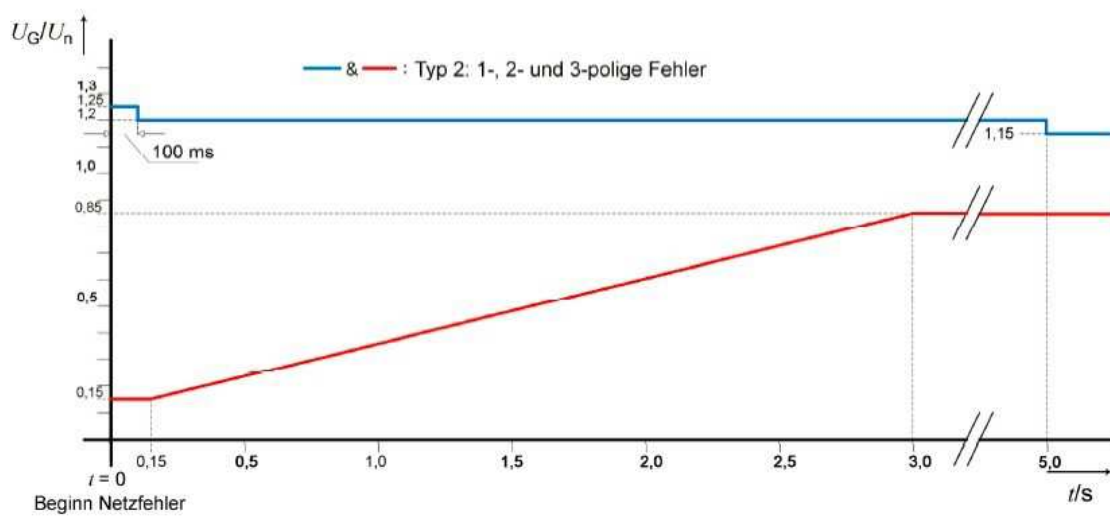
General

P

**FRT test for two-phase asymmetrical fault (Test ref no. x.3.x)**



Typ-B



**Legende**

— & — FRT-Kurve für 1-, 2- und 3-polige Netzfehler

UG Effektivwert der aktuellen Spannung an den Generatorklemmen

**Bild 12 – Fault-Ride-Through-Grenzkurve für den Spannungsverlauf an den Generatorklemmen für eine Erzeugungseinheit vom Typ 2 und für Speicher**

Figure 12 - Fault ride-through limit curve for the voltage curve at the generator terminals for a **type 2** generation unit and for storage

| 5.8.3 |  | Testing of the dynamic grid support |                               |                                      |                        |                                       |               | P                             |  |
|-------|--|-------------------------------------|-------------------------------|--------------------------------------|------------------------|---------------------------------------|---------------|-------------------------------|--|
|       |  | For PGUs Type 2 and storage systems |                               |                                      |                        |                                       |               | P                             |  |
|       |  | 1 and 3-phase systems               |                               |                                      |                        |                                       |               |                               |  |
| Test  | Voltage dip to (U <sub>n</sub> / p.u.) | Dip type                            | duration (ms) <sup>(2)*</sup> | P set point (P <sub>re</sub> / p.u.) | Q set point (Q / p.u.) | Comment                               | Test ref. No. | R recovery response time [ms] |  |
| 1     | 0,15 to 0,25                           | A                                   | for 0,15<br>≥ 150             | 1                                    | 0 to ± 0,1             | Symmetric                             | 1.1           | 775                           |  |
|       |  |                                     |                               | 0,2 to 0,6                           |                        |                                       | 1.2           | 105                           |  |
|       |  | D1                                  | /                             | 1                                    |                        | Asymmetric<br>(ph-2ph +<br>Dy5-Trafo) | 1.3           | N/A                           |  |
|       |  |                                     |                               | 0,2 to 0,6                           |                        |                                       | 1.4           | N/A                           |  |
|       |  | D2                                  | for 0,25<br>≥ 500             | 1                                    |                        | 1.5                                   | N/A           |                               |  |
|       |  |                                     |                               |                                      |                        |                                       |               |                               |  |
| 2     | 0,50 to 0,60                           | A                                   | for 0,50<br>≥ 1500            | 1                                    | Max. over<br>excited   | Symmetric                             | 2.1           | 394                           |  |
|       |  |                                     |                               | 0,2 to 0,6                           |                        |                                       | 2.2           | 252                           |  |
|       |  | D1                                  | /                             | 1                                    |                        | Asymmetric<br>(ph-2ph +<br>Dy5-Trafo) | 2.3           | N/A                           |  |
|       |  |                                     |                               | 0,2 to 0,6                           |                        |                                       | 2.4           | N/A                           |  |
| 3     | 0,50 to 0,60                           | A                                   | for 0,50<br>≥ 1500            | 1                                    | Max. under<br>excited  | Symmetric                             | 3.1           | 315                           |  |
|       |  |                                     |                               | 0,2 to 0,6                           |                        |                                       | 3.2           | 331                           |  |
|       |  | D1                                  | /                             | 1                                    |                        | Asymmetric<br>(ph-2ph +<br>Dy5-Trafo) | 3.3           | N/A                           |  |
|       |  |                                     |                               | 0,2 to 0,6                           |                        |                                       | 3.4           | N/A                           |  |
| 4     | 0,85 to 0,90                           | A                                   | ≥ 60000                       | 1                                    | 0 to ± 0,1             | Symmetric                             | 4.1           | 0                             |  |
|       |  |                                     |                               | 0,2 to 0,6                           |                        |                                       | 4.2           | 0                             |  |
|       |  | D1                                  |                               | 1                                    |                        | Asymmetric<br>(ph-2ph +<br>Dy5-Trafo) | 4.3           | N/A                           |  |
|       |  |                                     |                               | 0,2 to 0,6                           |                        |                                       | 4.4           | N/A                           |  |
| 5     | 1,20 to 1,25                           | A                                   | ≥ 100                         | 1                                    | 0 to ± 0,1             | Symmetric                             | 5.1           | 885                           |  |
|       |  |                                     |                               | 0,2 to 0,6                           |                        |                                       | 5.2           | 39                            |  |
|       |  | D1                                  |                               | 1                                    |                        | Asymmetric<br>(ph-2ph +<br>Dy5-Trafo) | 5.3           | N/A                           |  |
|       |  |                                     |                               | 0,2 to 0,6                           |                        |                                       | 5.4           | N/A                           |  |
|       |  | D2                                  |                               | 1                                    |                        | 5.5                                   | N/A           |                               |  |
|       |  |                                     |                               |                                      |                        |                                       |               |                               |  |
| 6     | 1,15 to 1,20                           | A                                   | ≥ 5000                        | 1                                    | 0 to ± 0,1             | Symmetric                             | 6.1           | 976                           |  |
|       |  |                                     |                               | 0,2 to 0,6                           |                        |                                       | 6.2           | 228                           |  |
|       |  | D1                                  |                               | 1                                    |                        | Asymmetric<br>(ph-2ph +<br>Dy5-Trafo) | 6.3           | N/A                           |  |
|       |  |                                     |                               | 0,2 to 0,6                           |                        |                                       | 6.4           | N/A                           |  |
| 7     | 1,10 to 1,15                           | A                                   | ≥ 60000                       | 1                                    | 0 to ± 0,1             | Symmetric                             | 7.1           | 630                           |  |
|       |  |                                     |                               | 0,2 to 0,6                           |                        |                                       | 7.2           | 236                           |  |
|       |  | D1                                  |                               | 1                                    |                        | Asymmetric<br>(ph-2ph +<br>Dy5-Trafo) | 7.3           | N/A                           |  |
|       |  |                                     |                               | 0,2 to 0,6                           |                        |                                       | 7.4           | N/A                           |  |

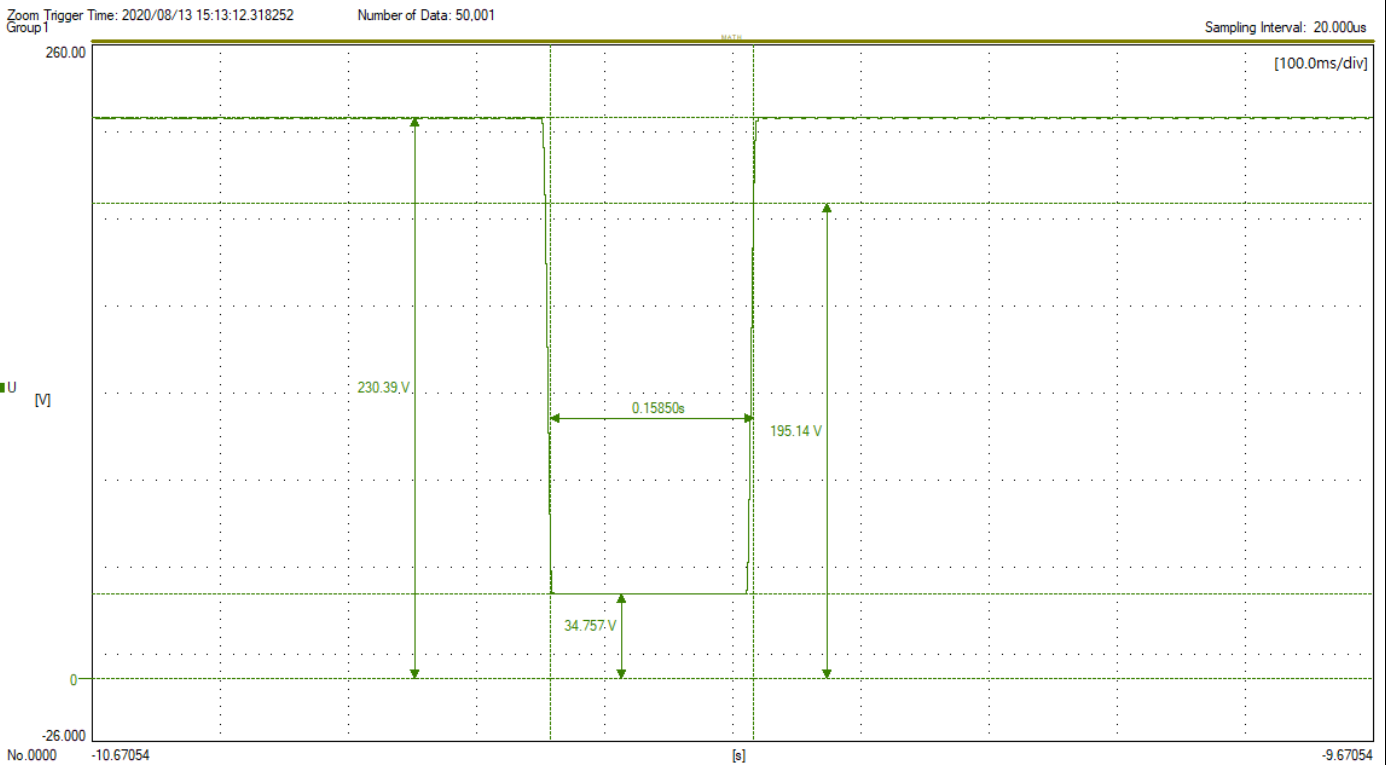
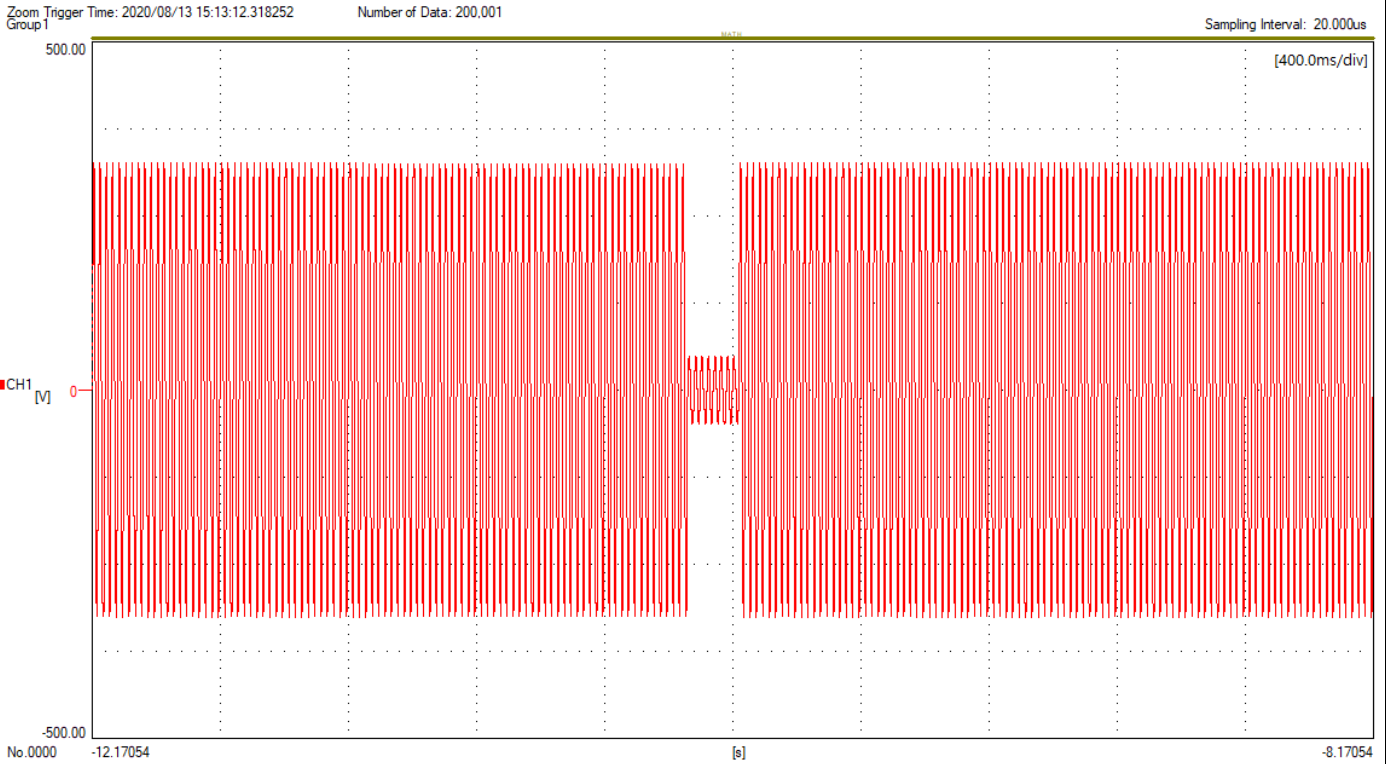
Note:



| 5.8.3   | Testing of the dynamic grid support | P |
|---|-------------------------------------|---|
| <p>* The EUT is single phase PV inverter which there is no Positive sequence, Zero sequence and Negative sequence distinguish between.</p> <p>At least The recording must begin at least 10s before the error occurs. After a faulty declaration (Voltage in the range <math>0,85 U_n \leq U \leq 1,1 U_n</math>), the recording must continue for at least another 60s.</p> <p>Behaviour during the network error:</p> <p>No disconnection of the PGU during the voltage drops the grid. If the PGU disconnects from the grid, the time of disconnection must be documented.</p> <ul style="list-style-type: none"><li>• Type 2 units and storage systems are not allowed to inject either active or reactive current during a line voltage at the PGUs terminals below <math>0,8 U_n</math> and above <math>1,15 U_n</math>. This requirement is met if, in the event of a under-/ under voltage dip, the injected current of the generating unit and / or the storage systems does not exceed 20% of the rated current <math>I_r</math> and no more than 10% <math>I_r</math> after 60ms after the occurrence of this under-/ under voltage dip in any phase.</li></ul> <p>Behaviour after the end of the error:</p> <ul style="list-style-type: none"><li>• Not disconnection of the PGU within 60s after the end of the fault.</li><li>• Type 2 units and storage systems: Reaction time of active power up to 1s, Reaction time of reactive power according to PT1 behaviour with <math>3 \tau = 10s</math> in accordance with VDE-AR-N 4105: 2018-11, 5.7.2.5</li></ul> <p>The tests had been performed on the SOFAR 3300TL-G3 is valid for the SOFAR 1100TL-G3, SOFAR 1600TL-G3, SOFAR 2200TL-G3, SOFAR 2700TL-G3 and SOFAR 3000TL-G3 since it is same as in hardware and just power derated by software.</p> |                                     |   |

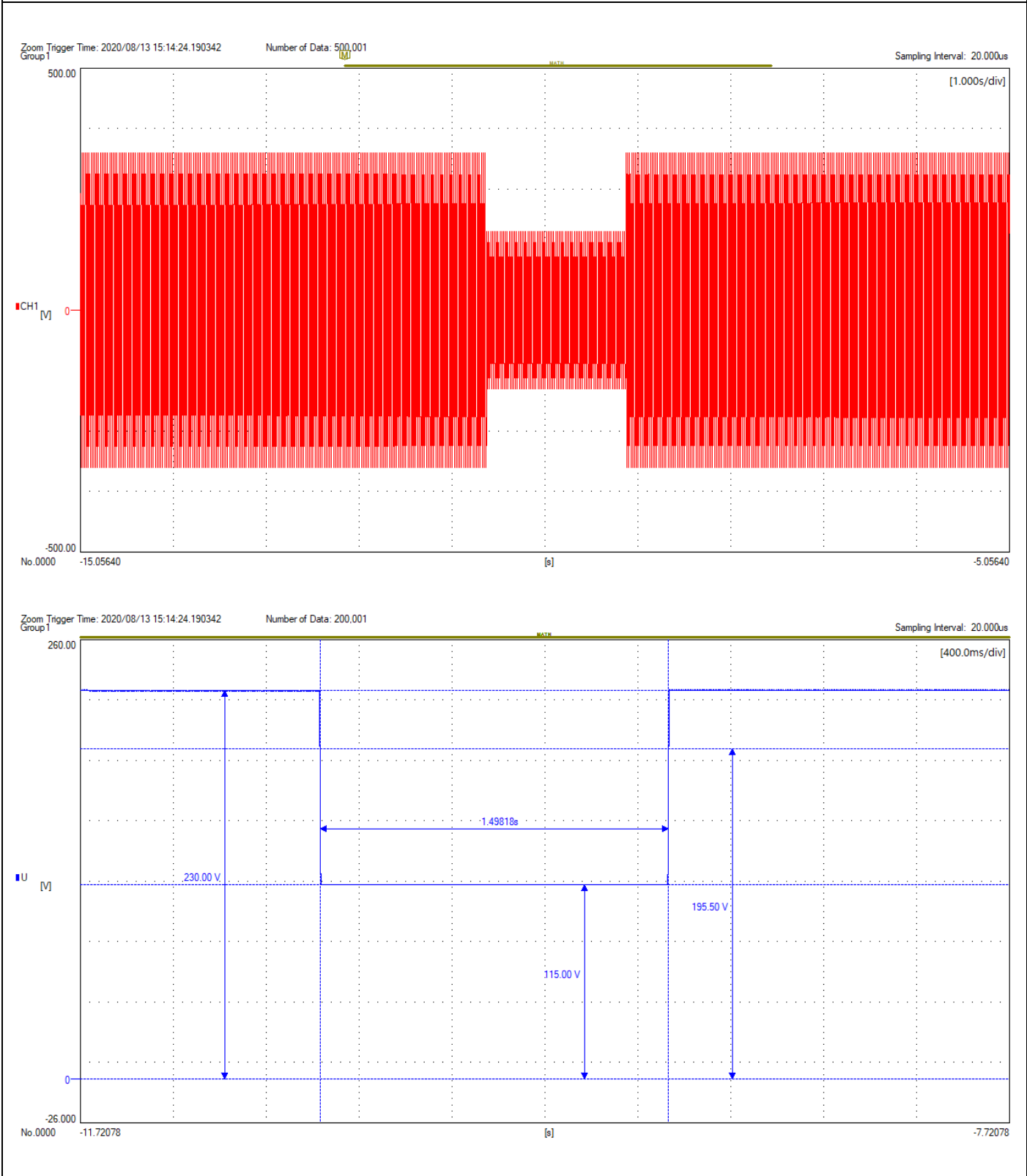
5.8.3 For PGUs Type 2 and storage systems – no load P

1.1



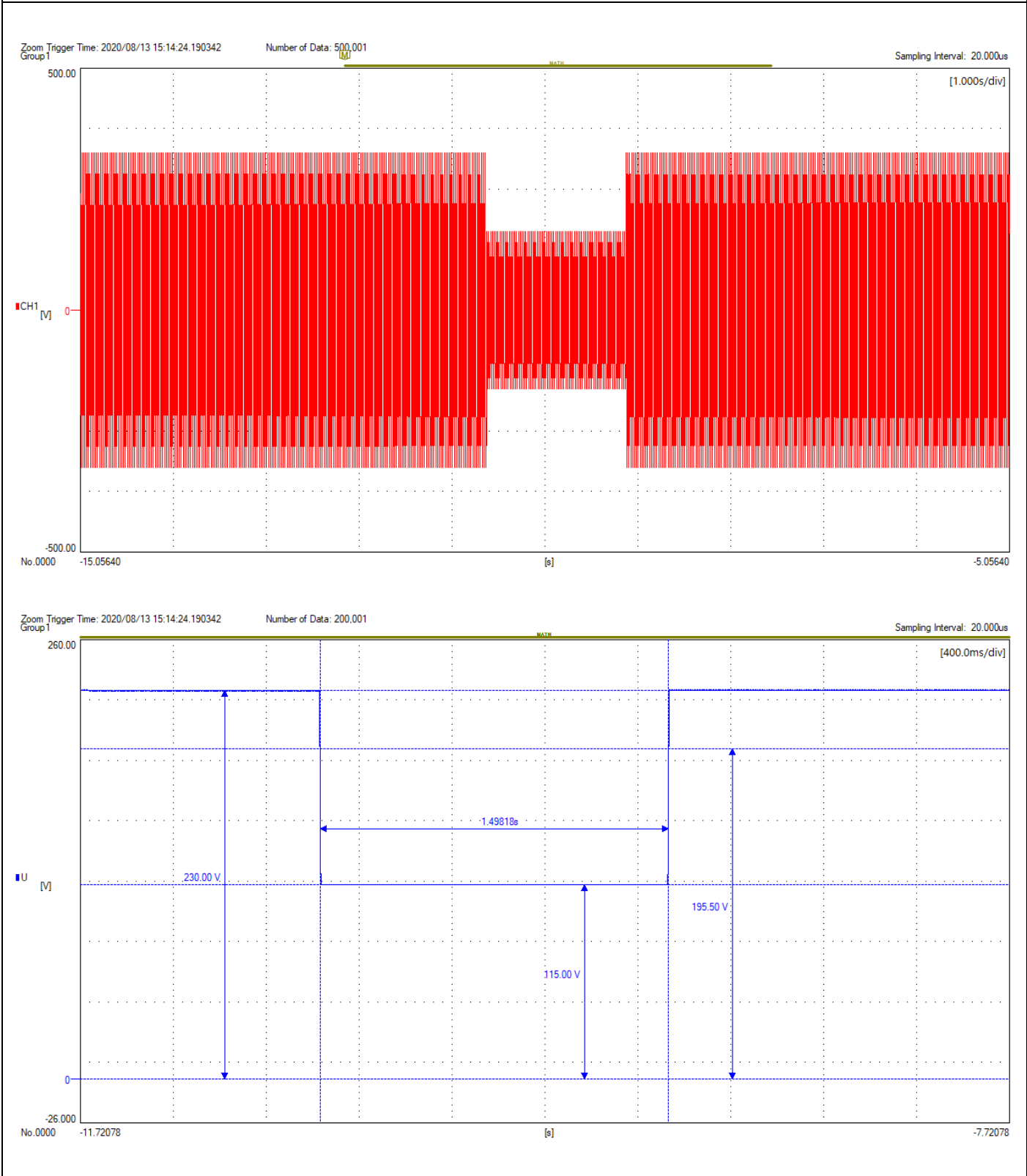
**5.8.3** For PGUs Type 2 and storage systems – no load **P**

**2.1**



**5.8.3** For PGUs Type 2 and storage systems – no load **P**

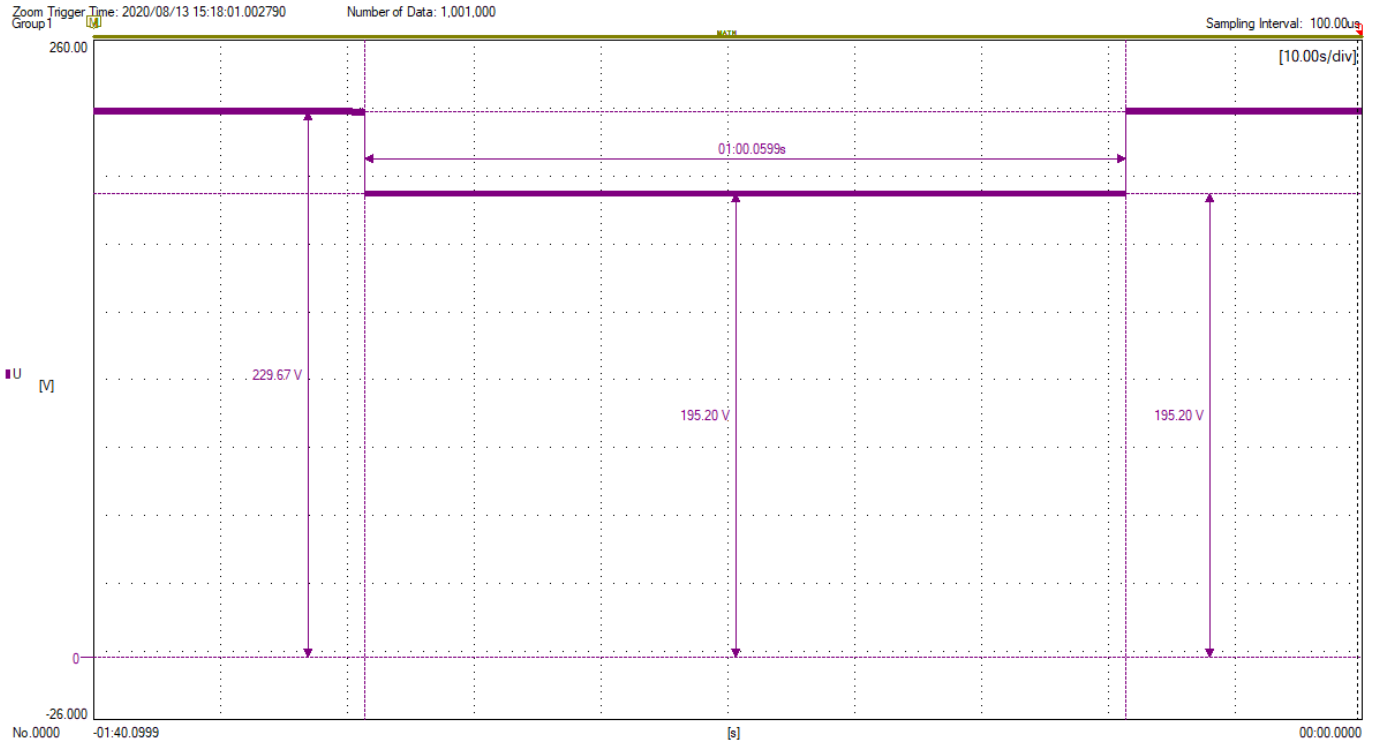
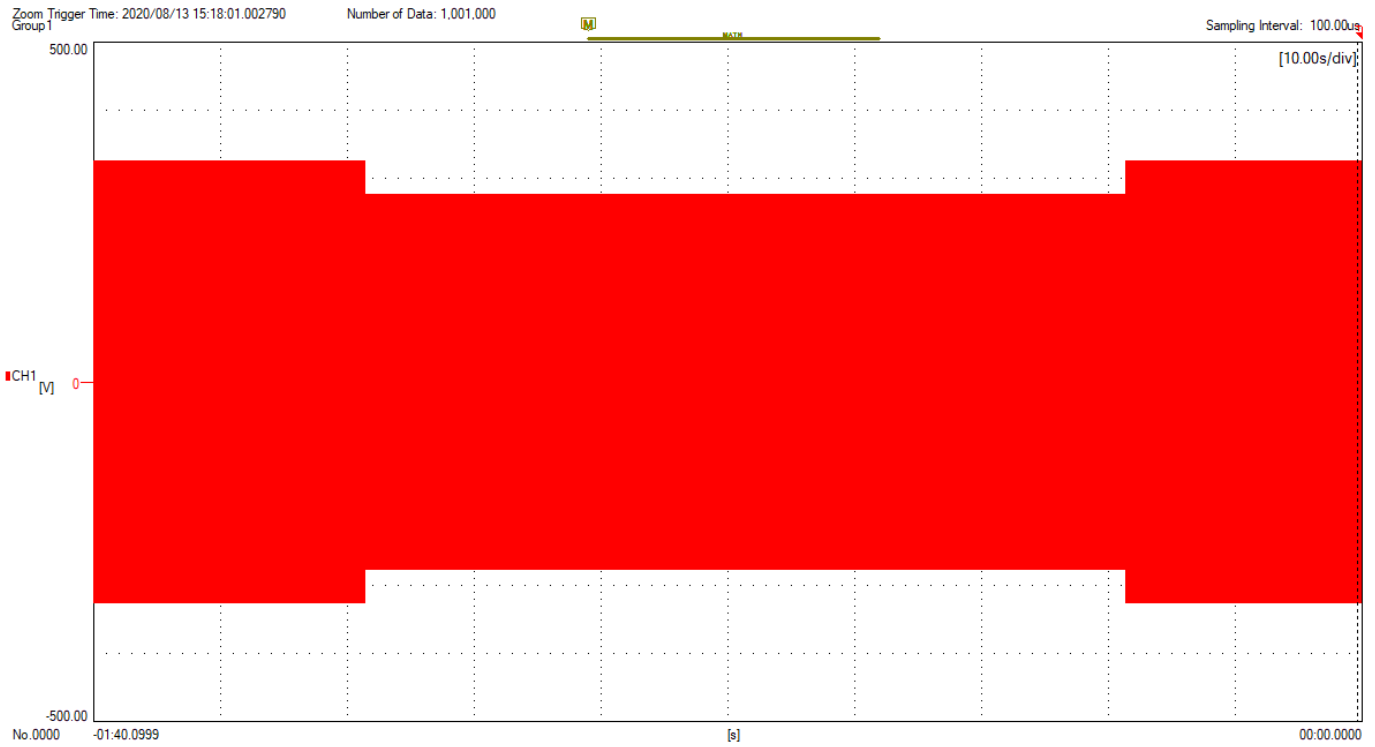
**3.1**





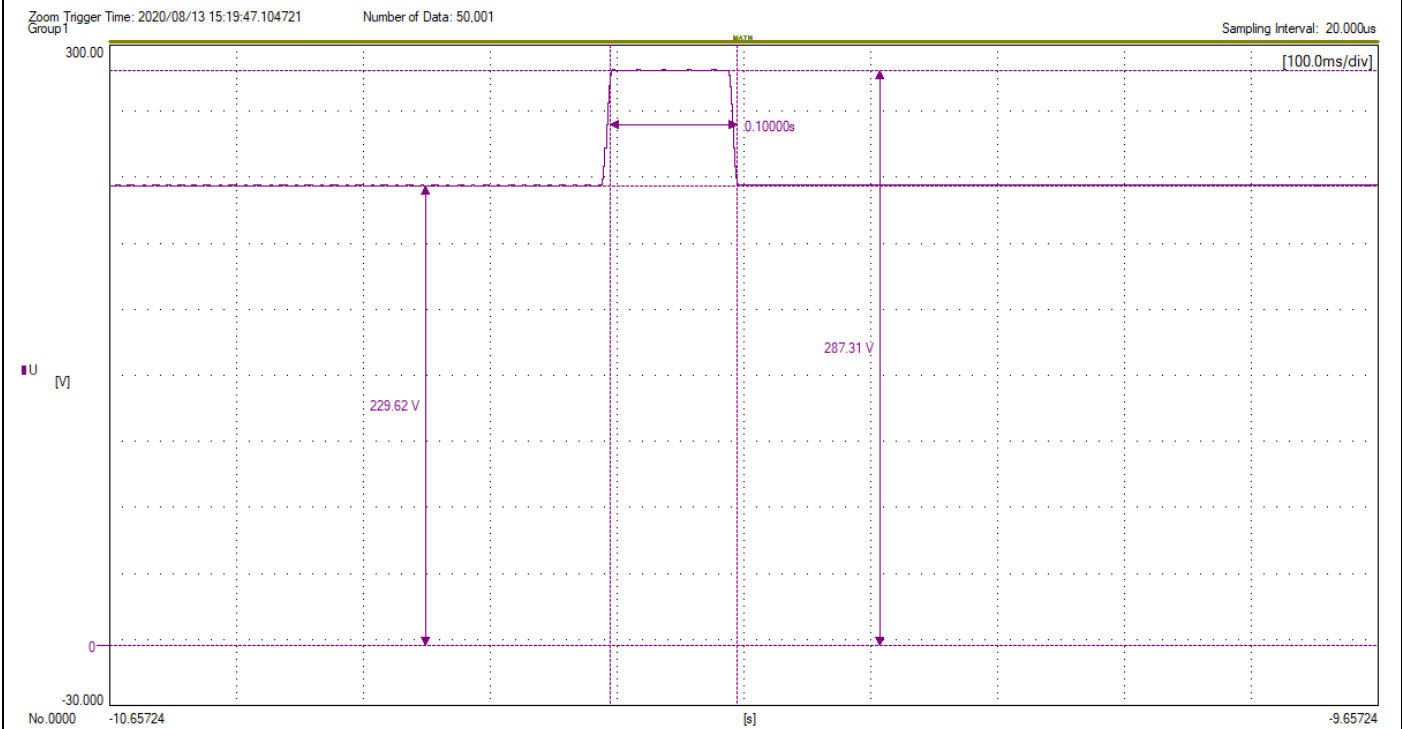
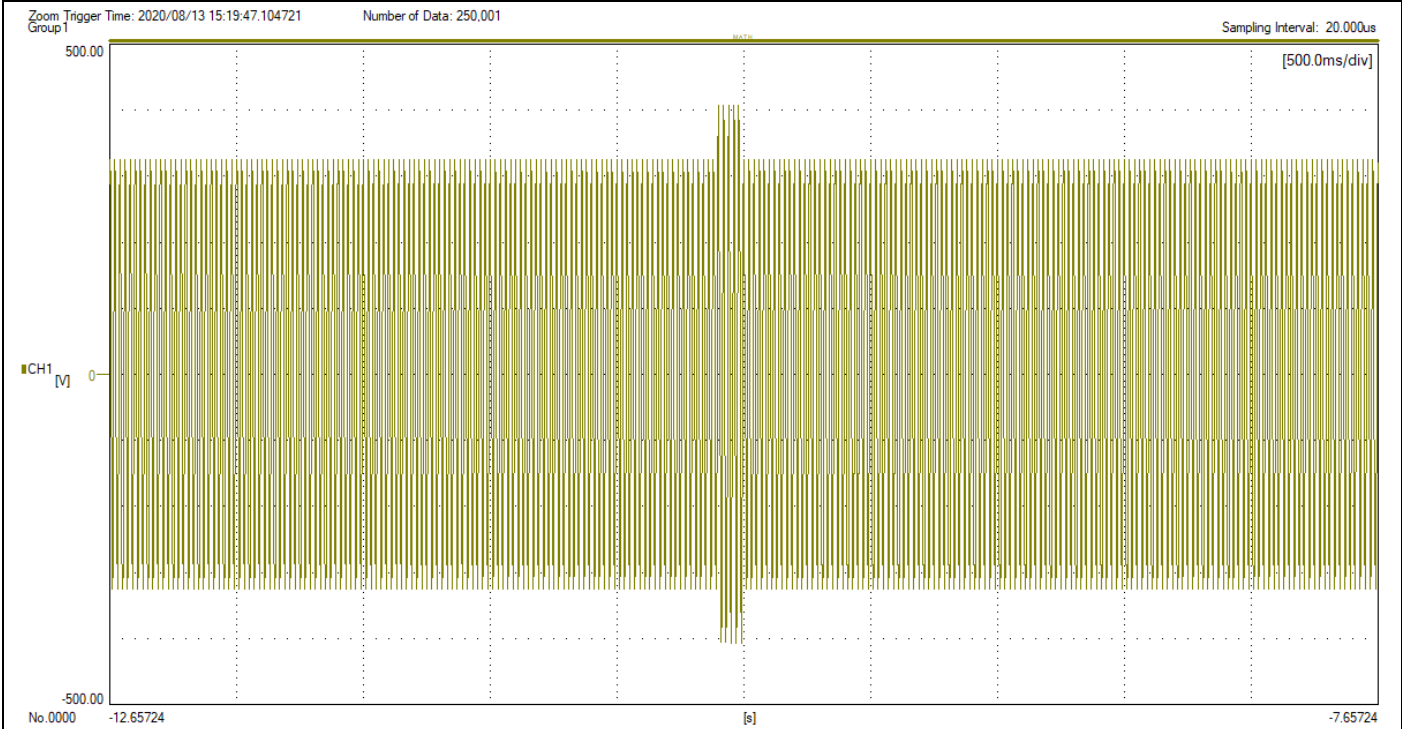
5.8.3 For PGUs Type 2 and storage systems – no load P

4.1



**5.8.3** For PGUs Type 2 and storage systems – no load **P**

**5.1**

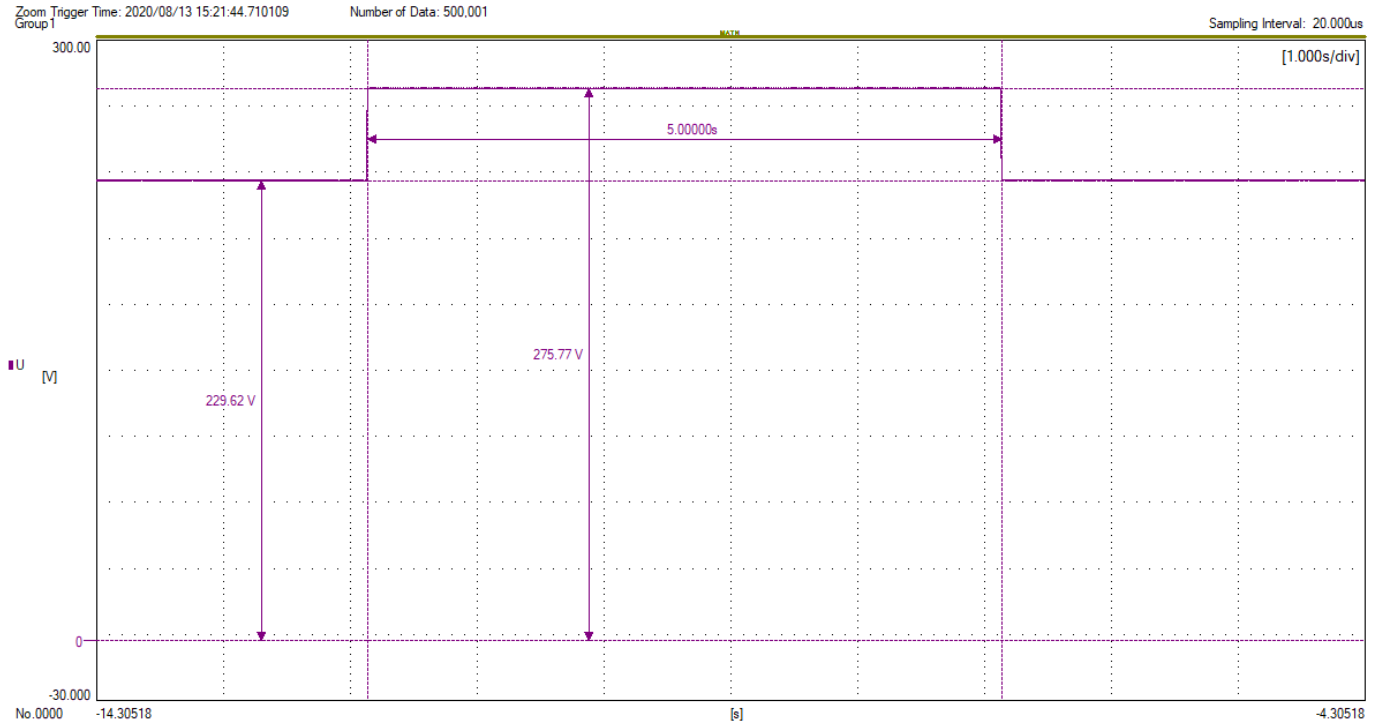
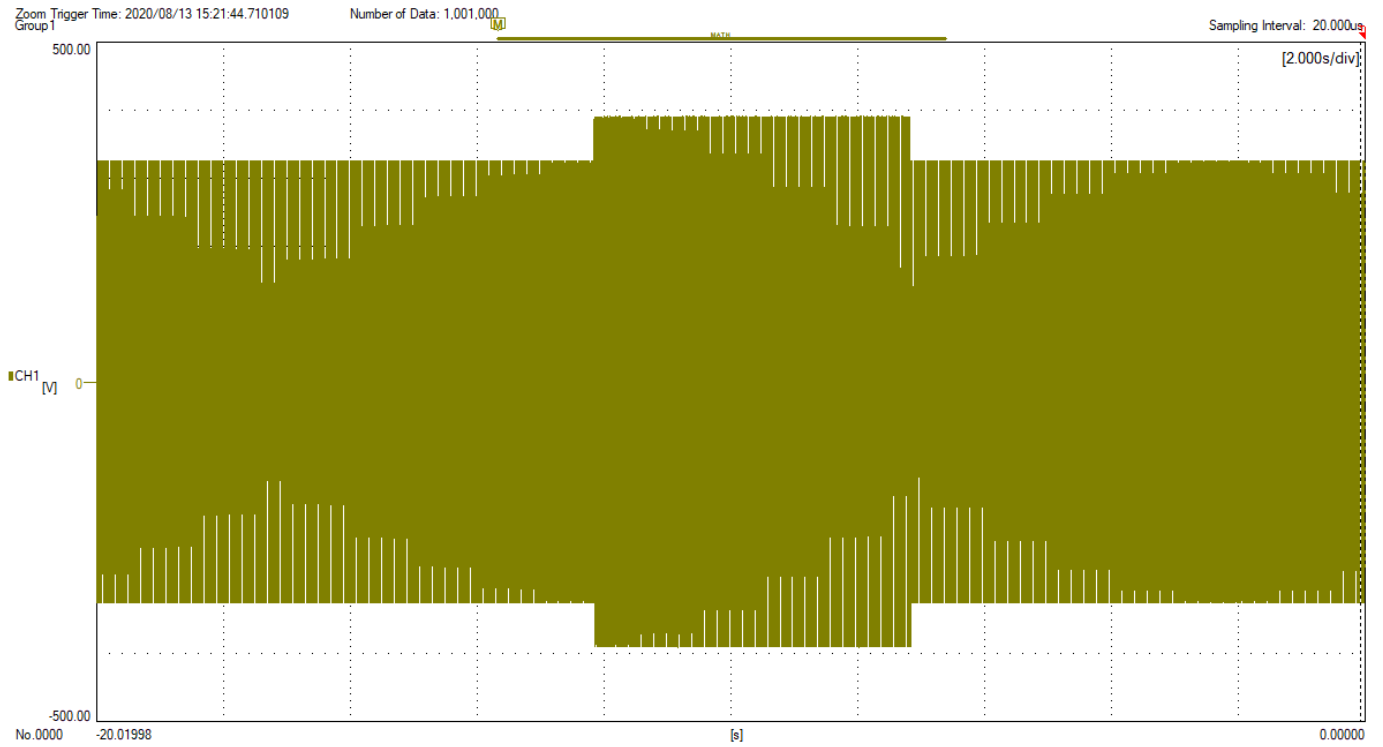


5.8.3

For PGUs Type 2 and storage systems – no load

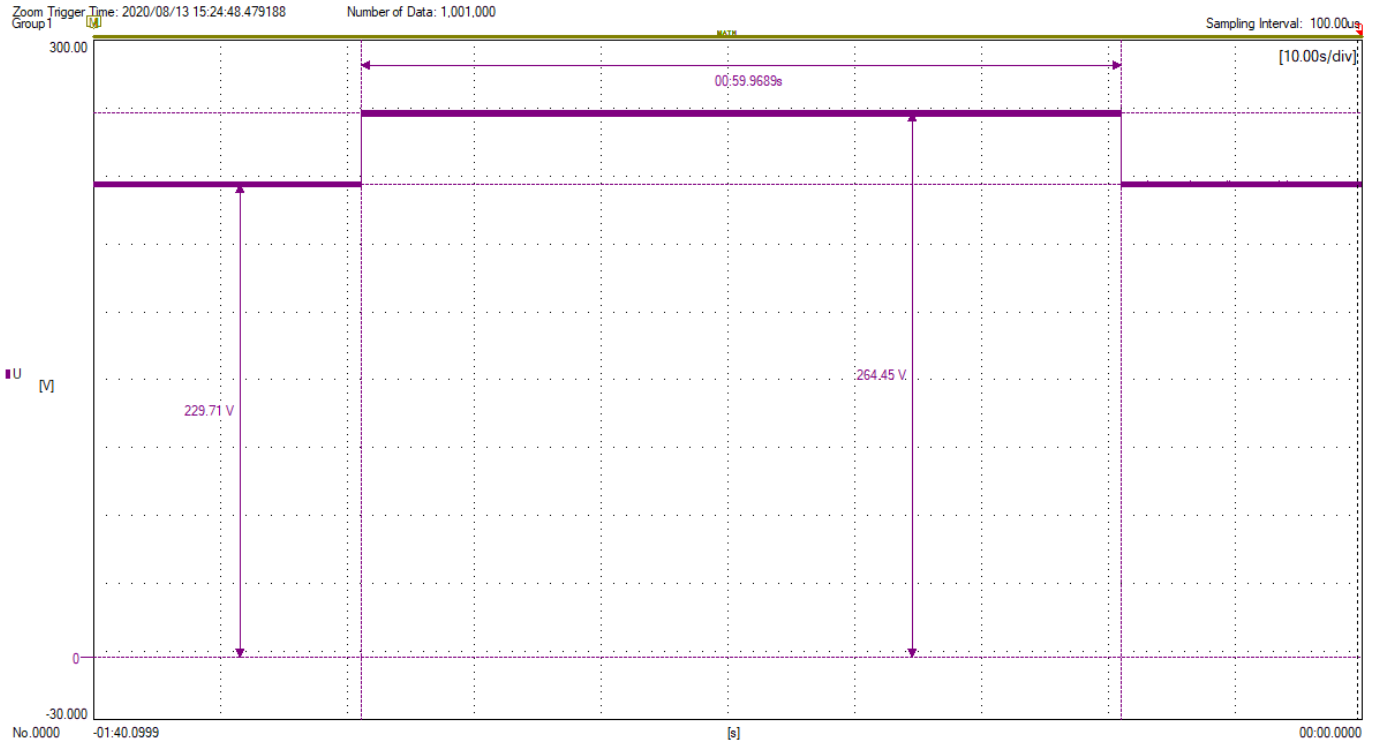
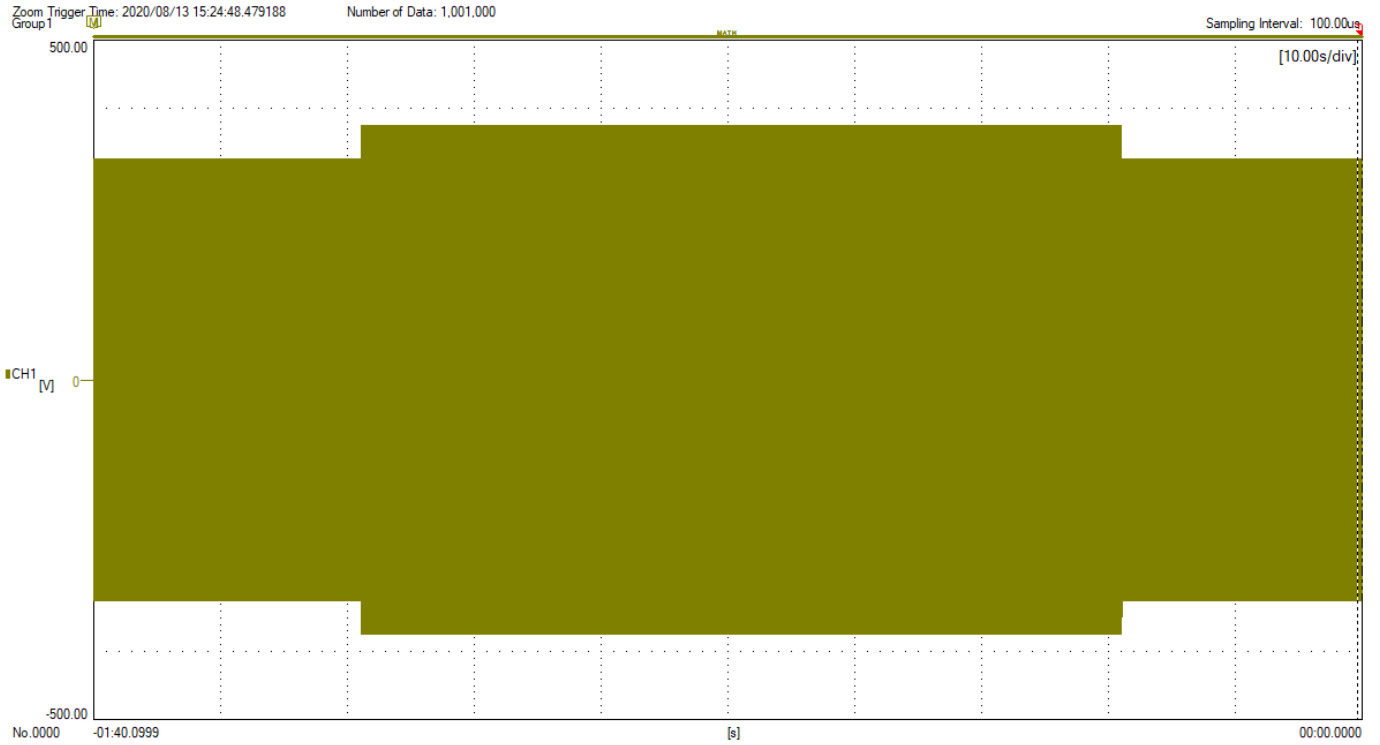
P

6.1



**5.8.3** For PGUs Type 2 and storage systems – no load **P**

**7.1**





**5.8.3 For PGUs Type 2 and storage systems P**

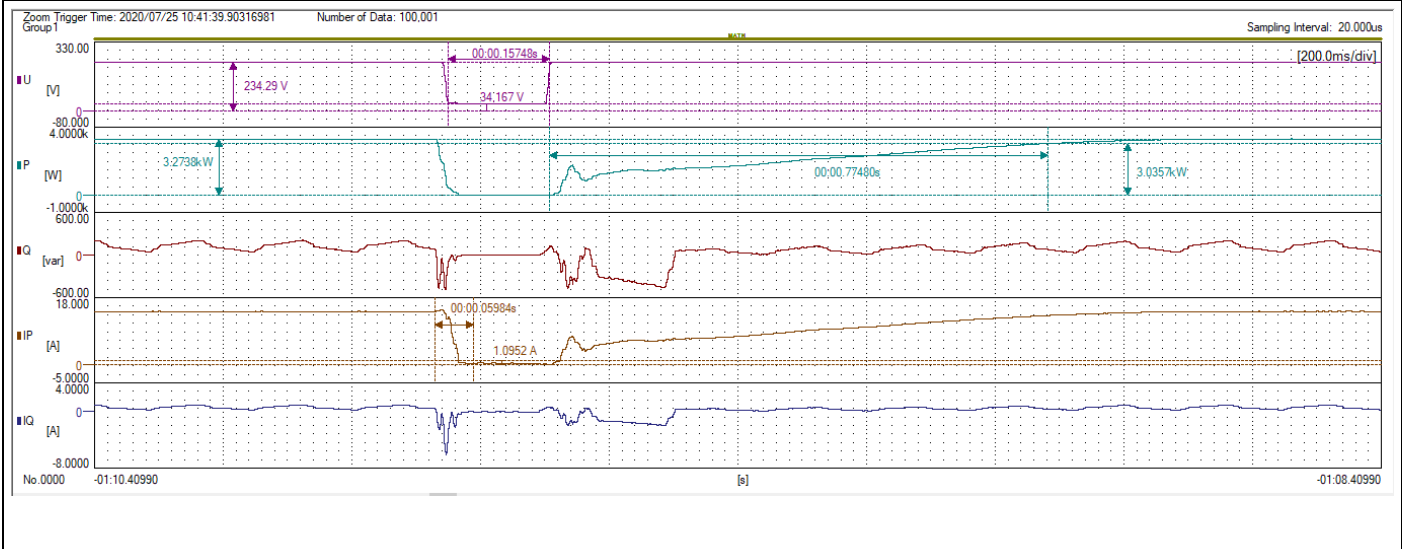
**1.1**

|                     | No.               | Parameter  | Phase reference   | Reference time                    | Value (unit) | Value        |
|---------------------|-------------------|--|-------------------|-----------------------------------|--------------|--------------|
| General information | 0                 | Test no.   | –                 | –                                 | –            | 1.1          |
|                     | 1                 | Date   | –                 | –                                 | [dd.mm.yyyy] | 25. 07. 2020 |
|                     | 2                 | Time ( Start of test)  | –                 | –                                 | [hh:mm:ss.f] | 10:41:39:903 |
|                     | 3                 | Type of fault (number of affected phases)                            | –                 | –                                 | –            | N/A          |
|                     | 4                 | Drop depth setpoint  | Phase             | –                                 | [p.u.]       | 0.15         |
|                     | 5                 | Drop duration setpoint   | Total             | –                                 | [ms]         | 150          |
|                     | 6                 | Fault occurrence (t1)  | Total             | –                                 | [ms]         | 69860        |
|                     | 7                 | Fault clearance (t2)   | Total             | –                                 | [ms]         | 69702        |
|                     | 8                 | Fault duration determined from test                                  | Total             | –                                 | [ms]         | 157.46       |
|                     | 9                 | Measured value of voltage drop / increase                            | Total             | t1+100 ms to t2 and t1-10 s to t1 | [p.u.]       | 0.78         |
| 10                  | Positive sequence |  | N/A               |                                   |              |              |
| Before t1           | 11                | Voltage  | Phase to Neutral  | t1-10 s to t1                     | [p.u.]       | 1.00         |
|                     | 12                | Current  | Positive sequence | t1-500 ms to t1-100 ms            | [p.u.]       | N/A          |
|                     | 13                | Active power   | Total             | t1-10 s to t1                     | [p.u.]       | 1.00         |
|                     | 14                |  | Positive sequence | t1-10 s to t1                     | [p.u.]       | N/A          |
|                     | 15                | Reactive power   | Positive sequence | t1-10 s to t1                     | [p.u.]       | N/A          |
|                     | 16                |  | Total             | t1-10 s to t1                     | [p.u.]       | 0.04         |
|                     | 17                | cos φ  | -                 | t1-10 s to t1                     | [p.u.]       | 1.00         |
| t1 till t2          | 18                | Voltage  | Phase to Neutral  | t1+100 ms to t2-20 ms             | [p.u.]       | 0.15         |
|                     | 19                | Phase current  | Phase 1           | t1+60 ms                          | [p.u.]       | 1.92         |
|                     | 20                |  | Phase 2           | t1+60 ms                          | [p.u.]       | N/A*         |
|                     | 21                |  | Phase 3           | t1+60 ms                          | [p.u.]       | N/A*         |
|                     | 22                | Phase current  | Phase 1           | t1 +100 ms                        | [p.u.]       | 2.39         |
|                     | 23                |  | Phase 2           | t1 +100 ms                        | [p.u.]       | N/A          |
|                     | 24                |  | Phase 3           | t1 +100 ms                        | [p.u.]       | N/A          |
|                     | 25                | Active power   | Total             | t1+100 ms to t2-20 ms             | [p.u.]       | 0.00         |
|                     | 26                |  | Positive sequence | t1+100 ms to t2-20 ms             | [p.u.]       | N/A          |
| After t2            | 27                | Voltage  | Phase to Neutral  | t2+3 s to t2+10 s                 | [p.u.]       | 1            |
|                     | 28                | Active power   | Positive sequence | t2+3 s to t2+10 s                 | [p.u.]       | N/A          |
|                     | 29                |  | Total             | t2+3 s to t2+10 s                 | [p.u.]       | 1.00         |
|                     | 30                | Response time active power   | Positive sequence | -                                 | [s]          | N/A          |
|                     | 31                | Reactive power   | Positive sequence | t2+3 s to t2+10 s                 | [p.u.]       | N/A          |
|                     | 32                |  | Total             | t2+3 s to t2+10 s                 | [p.u.]       | 0.04         |
|                     | 33                | Response time reactive power   | Positive sequence | -                                 | [s]          | N/A          |
|                     | 34                | EZE didn't disconnect from grid within 60s after fault ended yes/no? | –                 | t2 to t2+60s                      | –            | Yes          |

\* The EUT is single phase PV inverter which there is no Positive sequence, Zero sequence and Negative sequence distinguish between.



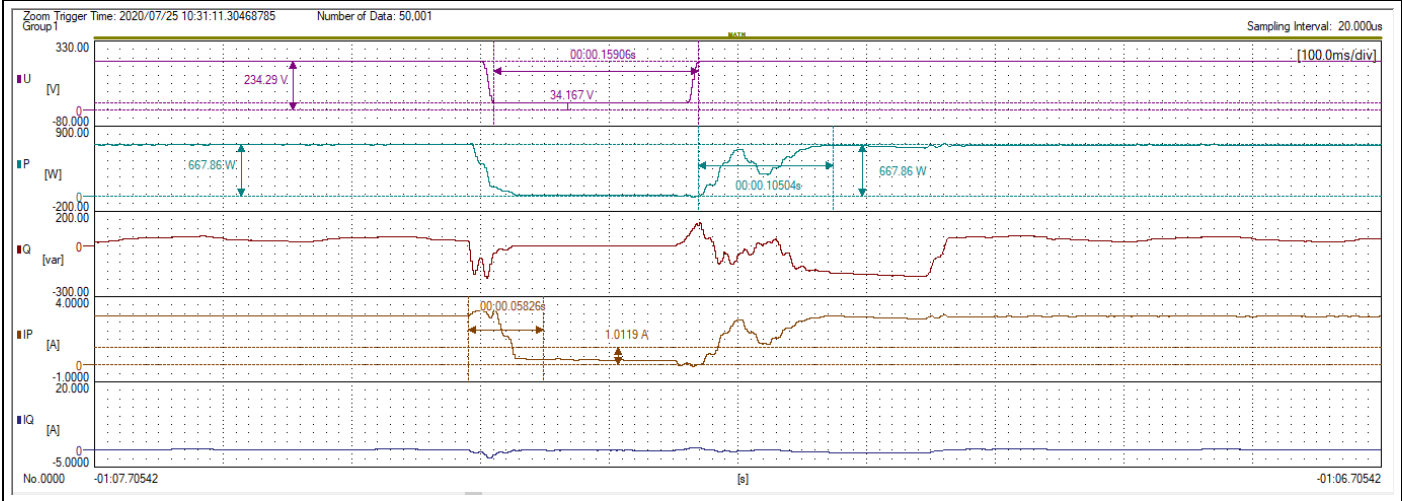
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| <b>5.8.3</b> | <b>For PGUs Type 2 and storage systems</b> | <b>P</b> |
|--------------|--|----------|



| 5.8.3               |                   | For PGUs Type 2 and storage systems                                  |                             |   |              | P            |
|---------------------|-------------------|--|-----------------------------|---|--------------|--------------|
| 1.2                 |                   |  |                             |   |              |              |
|                     | No.               | Parameter  | Phase reference             | Reference time                                | Value (unit) | Value        |
| General information | 0                 | Test no.   | –                           | –   | –            | 1.2          |
|                     | 1                 | Date   | –                           | –   | [dd.mm.yyyy] | 25. 07. 2020 |
|                     | 2                 | Time ( Start of test)  | –                           | –   | [hh:mm:ss.f] | 10:31:11.305 |
|                     | 3                 | Type of fault (number of affected phases)                            | –                           | –   | –            | N/A          |
|                     | 4                 | Drop depth setpoint  | Phase                       | –   | [p.u.]       | 0.15         |
|                     | 5                 | Drop duration setpoint   | Total                       | –   | [ms]         | 150          |
|                     | 6                 | Fault occurrence ( $t_1$ )   | Total                       | –   | [ms]         | 77396        |
|                     | 7                 | Fault clearance ( $t_2$ )  | Total                       | –   | [ms]         | 77237        |
|                     | 8                 | Fault duration determined from test                                  | Total                       | –   | [ms]         | 159          |
|                     | 9                 | Measured value of voltage drop / increase                            | Total                       | $t_1+100$ ms to $t_2$ and $t_1-10$ s to $t_1$ | [p.u.]       | 0.66         |
| 10                  | Positive sequence |  | N/A                         |   |              |              |
| Before $t_1$        | 11                | Voltage  | Phase to Neutral            | $t_1-10$ s to $t_1$                           | [p.u.]       | 1.00         |
|                     | 12                | Current  | Positive sequence           | $t_1-500$ ms to $t_1-100$ ms                  | [p.u.]       | N/A          |
|                     | 13                | Active power   | Total                       | $t_1-10$ s to $t_1$                           | [p.u.]       | 0.20         |
|                     | 14                |  | Positive sequence           | $t_1-10$ s to $t_1$                           | [p.u.]       | N/A          |
|                     | 15                | Reactive power   | Positive sequence           | $t_1-10$ s to $t_1$                           | [p.u.]       | N/A          |
|                     | 16                |  | Total                       | $t_1-10$ s to $t_1$                           | [p.u.]       | 0.01         |
|                     | 17                | $\cos \varphi$   | -                           | $t_1-10$ s to $t_1$                           | [p.u.]       | 1.00         |
| $t_1$ till $t_2$    | 18                | Voltage  | Phase to Neutral            | $t_1+100$ ms to $t_2-20$ ms                   | [p.u.]       | 0.15         |
|                     | 19                | Phase current  | Phase 1                     | $t_1+60$ ms                                   | [p.u.]       | 1.97         |
|                     | 20                |  | Phase 2                     | $t_1+60$ ms                                   | [p.u.]       | N/A*         |
|                     | 21                |  | Phase 3                     | $t_1+60$ ms                                   | [p.u.]       | N/A*         |
|                     | 22                | Phase current  | Phase 1                     | $t_1 +100$ ms                                 | [p.u.]       | 2.01         |
|                     | 23                |  | Phase 2                     | $t_1 +100$ ms                                 | [p.u.]       | N/A          |
|                     | 24                |  | Phase 3                     | $t_1 +100$ ms                                 | [p.u.]       | N/A          |
|                     | 25                | Active power   | Total                       | $t_1+100$ ms to $t_2-20$ ms                   | [p.u.]       | 0.00         |
| 26                  | Positive sequence |  | $t_1+100$ ms to $t_2-20$ ms | [p.u.]  | N/A          |              |
| After $t_2$         | 27                | Voltage  | Phase to Neutral            | $t_2+3$ s to $t_2+10$ s                       | [p.u.]       | 1            |
|                     | 28                | Active power   | Positive sequence           | $t_2+3$ s to $t_2+10$ s                       | [p.u.]       | N/A          |
|                     | 29                |  | Total                       | $t_2+3$ s to $t_2+10$ s                       | [p.u.]       | 0.20         |
|                     | 30                | Response time active power   | Positive sequence           | -   | [s]          | N/A          |
|                     | 31                | Reactive power   | Positive sequence           | $t_2+3$ s to $t_2+10$ s                       | [p.u.]       | N/A          |
|                     | 32                |  | Total                       | $t_2+3$ s to $t_2+10$ s                       | [p.u.]       | 0.01         |
|                     | 33                | Response time reactive power   | Positive sequence           | –   | [s]          | N/A          |
|                     | 34                | EZE didn't disconnect from grid within 60s after fault ended yes/no? | –                           | $t_2$ to $t_2+60$ s                           | –            | Yes          |



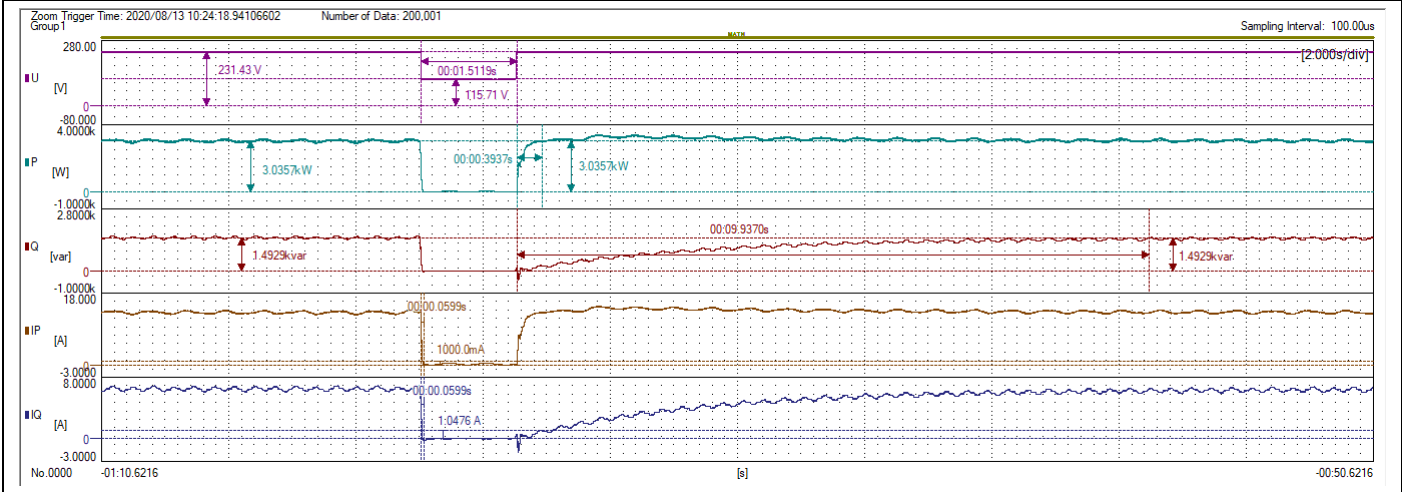
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| <b>5.8.3</b> | <b>For PGUs Type 2 and storage systems</b> | <b>P</b> |
|--------------|--|----------|



| 5.8.3               |                   | For PGUs Type 2 and storage systems                                  |                       |                                   |              | P            |
|---------------------|-------------------|--|-----------------------|-----------------------------------|--------------|--------------|
| 2.1                 |                   |  |                       |                                   |              |              |
|                     | No.               | Parameter  | Phase reference       | Reference time                    | Value (unit) | Value        |
| General information | 0                 | Test no.   | -                     | -                                 | -            | 2.1          |
|                     | 1                 | Date   | -                     | -                                 | [dd.mm.yyyy] | 13. 08. 2020 |
|                     | 2                 | Time ( Start of test)  | -                     | -                                 | [hh:mm:ss.f] | 10:24:18:941 |
|                     | 3                 | Type of fault (number of affected phases)                            | -                     | -                                 | -            | N/A          |
|                     | 4                 | Drop depth setpoint  | Phase                 | -                                 | [p.u.]       | 0.5          |
|                     | 5                 | Drop duration setpoint   | Total                 | -                                 | [ms]         | 150          |
|                     | 6                 | Fault occurrence (t1)  | Total                 | -                                 | [ms]         | 65599        |
|                     | 7                 | Fault clearance (t2)   | Total                 | -                                 | [ms]         | 64087        |
|                     | 8                 | Fault duration determined from test                                  | Total                 | -                                 | [ms]         | 1512         |
|                     | 9                 | Measured value of voltage drop / increase                            | Total                 | t1+100 ms to t2 and t1-10 s to t1 | [p.u.]       | 0.50         |
| 10                  | Positive sequence |  | N/A                   |                                   |              |              |
| Before t1           | 11                | Voltage  | Phase to Neutral      | t1-10 s to t1                     | [p.u.]       | 1.00         |
|                     | 12                | Current  | Positive sequence     | t1-500 ms to t1-100 ms            | [p.u.]       | N/A          |
|                     | 13                | Active power   | Total                 | t1-10 s to t1                     | [p.u.]       | 0.92         |
|                     | 14                |  | Positive sequence     | t1-10 s to t1                     | [p.u.]       | N/A          |
|                     | 15                | Reactive power   | Positive sequence     | t1-10 s to t1                     | [p.u.]       | N/A          |
|                     | 16                |  | Total                 | t1-10 s to t1                     | [p.u.]       | 0.00         |
|                     | 17                | cos φ  | -                     | t1-10 s to t1                     | [p.u.]       | 0.90         |
| t1 till t2          | 18                | Voltage  | Phase to Neutral      | t1+100 ms to t2-20 ms             | [p.u.]       | 0.15         |
|                     | 19                | Phase current  | Phase 1               | t1+60 ms                          | [p.u.]       | 1.92         |
|                     | 20                |  | Phase 2               | t1+60 ms                          | [p.u.]       | N/A*         |
|                     | 21                |  | Phase 3               | t1+60 ms                          | [p.u.]       | N/A*         |
|                     | 22                | Phase current  | Phase 1               | t1 +100 ms                        | [p.u.]       | 0.79         |
|                     | 23                |  | Phase 2               | t1 +100 ms                        | [p.u.]       | N/A          |
|                     | 24                |  | Phase 3               | t1 +100 ms                        | [p.u.]       | N/A          |
|                     | 25                | Active power   | Total                 | t1+100 ms to t2-20 ms             | [p.u.]       | 0.00         |
| 26                  | Positive sequence |  | t1+100 ms to t2-20 ms | [p.u.]                            | N/A          |              |
| After t2            | 27                | Voltage  | Phase to Neutral      | t2+3 s to t2+10 s                 | [p.u.]       | 1            |
|                     | 28                | Active power   | Positive sequence     | t2+3 s to t2+10 s                 | [p.u.]       | N/A          |
|                     | 29                |  | Total                 | t2+3 s to t2+10 s                 | [p.u.]       | 0.62         |
|                     | 30                | Response time active power   | Positive sequence     | -                                 | [s]          | N/A          |
|                     | 31                | Reactive power   | Positive sequence     | t2+3 s to t2+10 s                 | [p.u.]       | N/A          |
|                     | 32                |  | Total                 | t2+3 s to t2+10 s                 | [p.u.]       | 0.39         |
|                     | 33                | Response time reactive power   | Positive sequence     | -                                 | [s]          | N/A          |
|                     | 34                | EZE didn't disconnect from grid within 60s after fault ended yes/no? | -                     | t2 to t2+60s                      | -            | Yes          |



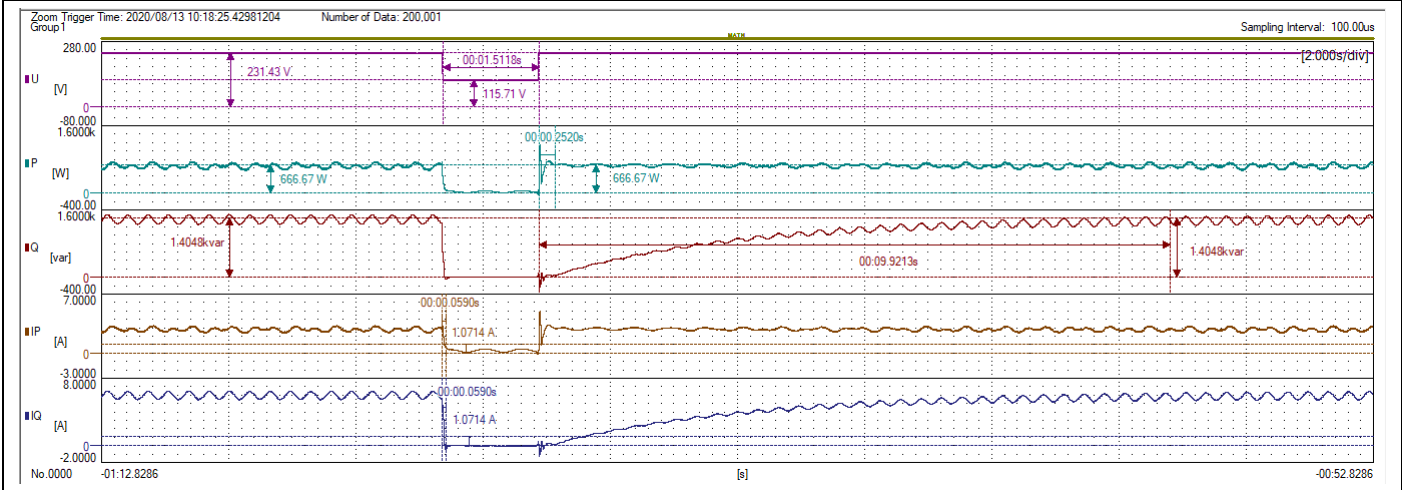
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| <b>5.8.3</b> | <b>For PGUs Type 2 and storage systems</b> | <b>P</b> |
|--------------|--|----------|



| 5.8.3               |                   | For PGUs Type 2 and storage systems                                  |                       |                                   |              | P            |
|---------------------|-------------------|--|-----------------------|-----------------------------------|--------------|--------------|
| 2.2                 |                   |  |                       |                                   |              |              |
|                     | No.               | Parameter  | Phase reference       | Reference time                    | Value (unit) | Value        |
| General information | 0                 | Test no.   | -                     | -                                 | -            | 2.2          |
|                     | 1                 | Date   | -                     | -                                 | [dd.mm.yyyy] | 13. 08. 2020 |
|                     | 2                 | Time ( Start of test)  | -                     | -                                 | [hh:mm:ss.f] | 10:18:25:430 |
|                     | 3                 | Type of fault (number of affected phases)                            | -                     | -                                 | -            | N/A          |
|                     | 4                 | Drop depth setpoint  | Phase                 | -                                 | [p.u]        | 0.5          |
|                     | 5                 | Drop duration setpoint   | Total                 | -                                 | [ms]         | 150          |
|                     | 6                 | Fault occurrence (t1)  | Total                 | -                                 | [ms]         | 67455        |
|                     | 7                 | Fault clearance (t2)   | Total                 | -                                 | [ms]         | 65943        |
|                     | 8                 | Fault duration determined from test                                  | Total                 | -                                 | [ms]         | 1512         |
|                     | 9                 | Measured value of voltage drop / increase                            | Total                 | t1+100 ms to t2 and t1-10 s to t1 | [p.u.]       | 0.49         |
| 10                  | Positive sequence |  | N/A                   |                                   |              |              |
| Before t1           | 11                | Voltage  | Phase to Neutral      | t1-10 s to t1                     | [p.u.]       | 1.00         |
|                     | 12                | Current  | Positive sequence     | t1-500 ms to t1-100 ms            | [p.u.]       | N/A          |
|                     | 13                | Active power   | Total                 | t1-10 s to t1                     | [p.u.]       | 0.20         |
|                     | 14                |  | Positive sequence     | t1-10 s to t1                     | [p.u.]       | N/A          |
|                     | 15                | Reactive power   | Positive sequence     | t1-10 s to t1                     | [p.u.]       | N/A          |
|                     | 16                |  | Total                 | t1-10 s to t1                     | [p.u.]       | 0.00         |
|                     | 17                | cos φ  | -                     | t1-10 s to t1                     | [p.u.]       | 0.43         |
| t1 till t2          | 18                | Voltage  | Phase to Neutral      | t1+100 ms to t2-20 ms             | [p.u.]       | 0.15         |
|                     | 19                | Phase current  | Phase 1               | t1+60 ms                          | [p.u.]       | 3.90         |
|                     | 20                |  | Phase 2               | t1+60 ms                          | [p.u.]       | N/A*         |
|                     | 21                |  | Phase 3               | t1+60 ms                          | [p.u.]       | N/A*         |
|                     | 22                | Phase current  | Phase 1               | t1 +100 ms                        | [p.u.]       | 2.64         |
|                     | 23                |  | Phase 2               | t1 +100 ms                        | [p.u.]       | N/A          |
|                     | 24                |  | Phase 3               | t1 +100 ms                        | [p.u.]       | N/A          |
|                     | 25                | Active power   | Total                 | t1+100 ms to t2-20 ms             | [p.u.]       | 0.00         |
| 26                  | Positive sequence |  | t1+100 ms to t2-20 ms | [p.u.]                            | N/A          |              |
| After t2            | 27                | Voltage  | Phase to Neutral      | t2+3 s to t2+10 s                 | [p.u.]       | 1            |
|                     | 28                | Active power   | Positive sequence     | t2+3 s to t2+10 s                 | [p.u.]       | N/A          |
|                     | 29                |  | Total                 | t2+3 s to t2+10 s                 | [p.u.]       | 0.20         |
|                     | 30                | Response time active power   | Positive sequence     | -                                 | [s]          | N/A          |
|                     | 31                | Reactive power   | Positive sequence     | t2+3 s to t2+10 s                 | [p.u.]       | N/A          |
|                     | 32                |  | Total                 | t2+3 s to t2+10 s                 | [p.u.]       | 0.36         |
|                     | 33                | Response time reactive power   | Positive sequence     | -                                 | [s]          | N/A          |
|                     | 34                | EZE didn't disconnect from grid within 60s after fault ended yes/no? | -                     | t2 to t2+60s                      | -            | Yes          |



|              |  |          |
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| <b>5.8.3</b> | <b>For PGUs Type 2 and storage systems</b> | <b>P</b> |
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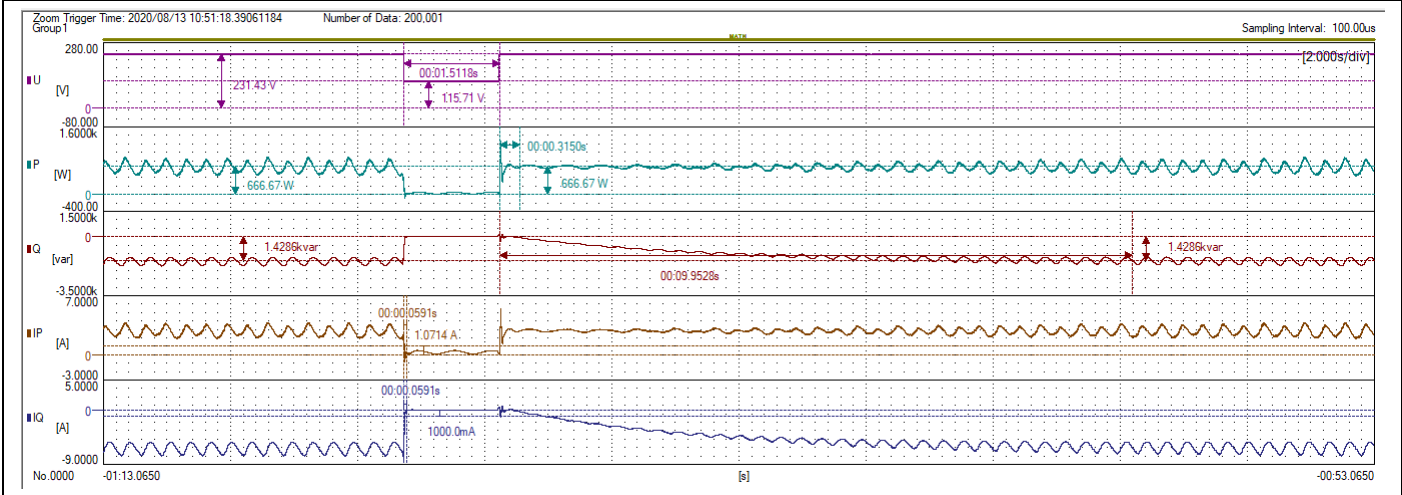




| 5.8.3               |                   | For PGUs Type 2 and storage systems                                  |                       |                                   |              | P            |
|---------------------|-------------------|--|-----------------------|-----------------------------------|--------------|--------------|
| 3.1                 |                   |  |                       |                                   |              |              |
|                     | No.               | Parameter  | Phase reference       | Reference time                    | Value (unit) | Value        |
| General information | 0                 | Test no.   | -                     | -                                 | -            | 3.1          |
|                     | 1                 | Date   | -                     | -                                 | [dd.mm.yyyy] | 13. 08. 2020 |
|                     | 2                 | Time ( Start of test)  | -                     | -                                 | [hh:mm:ss.f] | 10:51:18:391 |
|                     | 3                 | Type of fault (number of affected phases)                            | -                     | -                                 | -            | N/A          |
|                     | 4                 | Drop depth setpoint  | Phase                 | -                                 | [p.u]        | 0.5          |
|                     | 5                 | Drop duration setpoint   | Total                 | -                                 | [ms]         | 1500         |
|                     | 6                 | Fault occurrence (t1)  | Total                 | -                                 | [ms]         | 68340        |
|                     | 7                 | Fault clearance (t2)   | Total                 | -                                 | [ms]         | 76835        |
|                     | 8                 | Fault duration determined from test                                  | Total                 | -                                 | [ms]         | 1505         |
|                     | 9                 | Measured value of voltage drop / increase                            | Total                 | t1+100 ms to t2 and t1-10 s to t1 | [p.u.]       | 0.50         |
| 10                  | Positive sequence |  | N/A                   |                                   |              |              |
| Before t1           | 11                | Voltage  | Phase to Neutral      | t1-10 s to t1                     | [p.u.]       | 1.00         |
|                     | 12                | Current  | Positive sequence     | t1-500 ms to t1-100 ms            | [p.u.]       | N/A          |
|                     | 13                | Active power   | Total                 | t1-10 s to t1                     | [p.u.]       | 0.13         |
|                     | 14                |  | Positive sequence     | t1-10 s to t1                     | [p.u.]       | N/A          |
|                     | 15                | Reactive power   | Positive sequence     | t1-10 s to t1                     | [p.u.]       | N/A          |
|                     | 16                |  | Total                 | t1-10 s to t1                     | [p.u.]       | 0.30         |
|                     | 17                | cos φ  | -                     | t1-10 s to t1                     | [p.u.]       | 0.40         |
| t1 till t2          | 18                | Voltage  | Phase to Neutral      | t1+100 ms to t2-20 ms             | [p.u.]       | 0.15         |
|                     | 19                | Phase current  | Phase 1               | t1+60 ms                          | [p.u.]       | 0.92         |
|                     | 20                |  | Phase 2               | t1+60 ms                          | [p.u.]       | N/A*         |
|                     | 21                |  | Phase 3               | t1+60 ms                          | [p.u.]       | N/A*         |
|                     | 22                | Phase current  | Phase 1               | t1 +100 ms                        | [p.u.]       | 1.27         |
|                     | 23                |  | Phase 2               | t1 +100 ms                        | [p.u.]       | N/A          |
|                     | 24                |  | Phase 3               | t1 +100 ms                        | [p.u.]       | N/A          |
|                     | 25                | Active power   | Total                 | t1+100 ms to t2-20 ms             | [p.u.]       | 0.01         |
| 26                  | Positive sequence |  | t1+100 ms to t2-20 ms | [p.u.]                            | N/A          |              |
| After t2            | 27                | Voltage  | Phase to Neutral      | t2+3 s to t2+10 s                 | [p.u.]       | 1            |
|                     | 28                | Active power   | Positive sequence     | t2+3 s to t2+10 s                 | [p.u.]       | N/A          |
|                     | 29                |  | Total                 | t2+3 s to t2+10 s                 | [p.u.]       | 0.20         |
|                     | 30                | Response time active power   | Positive sequence     | -                                 | [s]          | N/A          |
|                     | 31                | Reactive power   | Positive sequence     | t2+3 s to t2+10 s                 | [p.u.]       | N/A          |
|                     | 32                |  | Total                 | t2+3 s to t2+10 s                 | [p.u.]       | 0.39         |
|                     | 33                | Response time reactive power   | Positive sequence     | -                                 | [s]          | N/A          |
|                     | 34                | EZE didn't disconnect from grid within 60s after fault ended yes/no? | -                     | t2 to t2+60s                      | -            | Yes          |



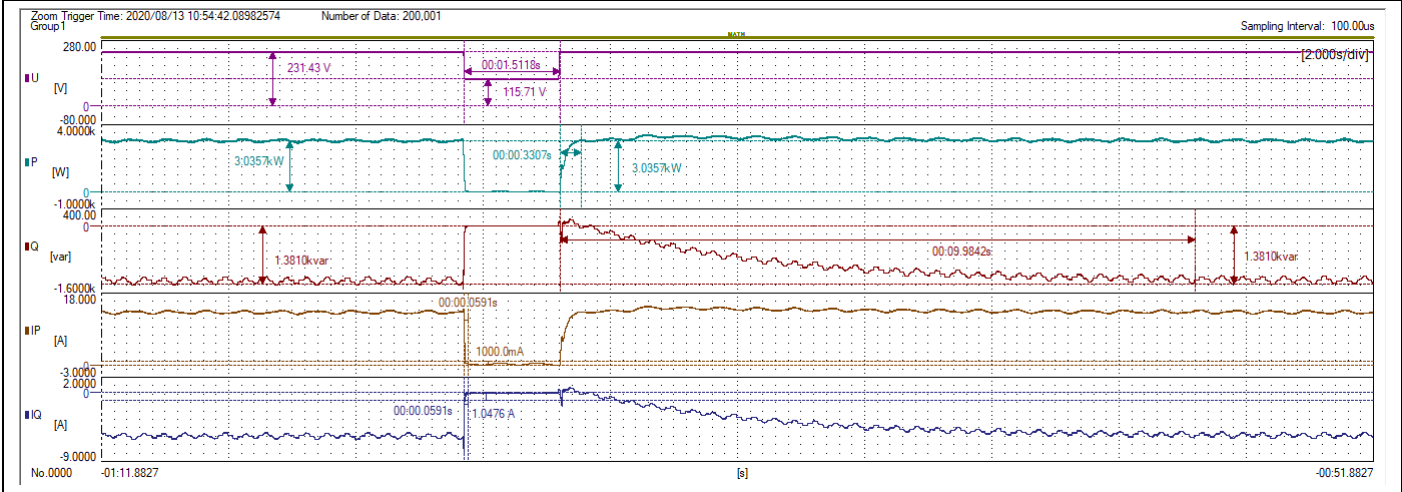
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| <b>5.8.3</b> | <b>For PGUs Type 2 and storage systems</b> | <b>P</b> |
|--------------|--|----------|



| 5.8.3               |                   | For PGUs Type 2 and storage systems                                  |                       |                                   |              | P            |
|---------------------|-------------------|--|-----------------------|-----------------------------------|--------------|--------------|
| 3.2                 |                   |  |                       |                                   |              |              |
|                     | No.               | Parameter  | Phase reference       | Reference time                    | Value (unit) | Value        |
| General information | 0                 | Test no.   | -                     | -                                 | -            | 3.2          |
|                     | 1                 | Date   | -                     | -                                 | [dd.mm.yyyy] | 13. 08. 2020 |
|                     | 2                 | Time ( Start of test)  | -                     | -                                 | [hh:mm:ss.f] | 10:54:42:090 |
|                     | 3                 | Type of fault (number of affected phases)                            | -                     | -                                 | -            | N/A          |
|                     | 4                 | Drop depth setpoint  | Phase                 | -                                 | [p.u]        | 0.5          |
|                     | 5                 | Drop duration setpoint   | Total                 | -                                 | [ms]         | 1500         |
|                     | 6                 | Fault occurrence (t1)  | Total                 | -                                 | [ms]         | 66180        |
|                     | 7                 | Fault clearance (t2)   | Total                 | -                                 | [ms]         | 64668        |
|                     | 8                 | Fault duration determined from test                                  | Total                 | -                                 | [ms]         | 1512         |
|                     | 9                 | Measured value of voltage drop / increase                            | Total                 | t1+100 ms to t2 and t1-10 s to t1 | [p.u.]       | 0.50         |
| 10                  | Positive sequence |  | N/A                   |                                   |              |              |
| Before t1           | 11                | Voltage  | Phase to Neutral      | t1-10 s to t1                     | [p.u.]       | 1.00         |
|                     | 12                | Current  | Positive sequence     | t1-500 ms to t1-100 ms            | [p.u.]       | N/A          |
|                     | 13                | Active power   | Total                 | t1-10 s to t1                     | [p.u.]       | 0.92         |
|                     | 14                |  | Positive sequence     | t1-10 s to t1                     | [p.u.]       | N/A          |
|                     | 15                | Reactive power   | Positive sequence     | t1-10 s to t1                     | [p.u.]       | N/A          |
|                     | 16                |  | Total                 | t1-10 s to t1                     | [p.u.]       | 0.26         |
|                     | 17                | cos φ  | -                     | t1-10 s to t1                     | [p.u.]       | 0.92         |
| t1 till t2          | 18                | Voltage  | Phase to Neutral      | t1+100 ms to t2-20 ms             | [p.u.]       | 0.15         |
|                     | 19                | Phase current  | Phase 1               | t1+60 ms                          | [p.u.]       | 2.47         |
|                     | 20                |  | Phase 2               | t1+60 ms                          | [p.u.]       | N/A*         |
|                     | 21                |  | Phase 3               | t1+60 ms                          | [p.u.]       | N/A*         |
|                     | 22                | Phase current  | Phase 1               | t1 +100 ms                        | [p.u.]       | 2.10         |
|                     | 23                |  | Phase 2               | t1 +100 ms                        | [p.u.]       | N/A          |
|                     | 24                |  | Phase 3               | t1 +100 ms                        | [p.u.]       | N/A          |
|                     | 25                | Active power   | Total                 | t1+100 ms to t2-20 ms             | [p.u.]       | 0.01         |
| 26                  | Positive sequence |  | t1+100 ms to t2-20 ms | [p.u.]                            | N/A          |              |
| After t2            | 27                | Voltage  | Phase to Neutral      | t2+3 s to t2+10 s                 | [p.u.]       | 1            |
|                     | 28                | Active power   | Positive sequence     | t2+3 s to t2+10 s                 | [p.u.]       | N/A          |
|                     | 29                |  | Total                 | t2+3 s to t2+10 s                 | [p.u.]       | 0.95         |
|                     | 30                | Response time active power   | Positive sequence     | -                                 | [s]          | N/A          |
|                     | 31                | Reactive power   | Positive sequence     | t2+3 s to t2+10 s                 | [p.u.]       | N/A          |
|                     | 32                |  | Total                 | t2+3 s to t2+10 s                 | [p.u.]       | 0.34         |
|                     | 33                | Response time reactive power   | Positive sequence     | -                                 | [s]          | N/A          |
|                     | 34                | EZE didn't disconnect from grid within 60s after fault ended yes/no? | -                     | t2 to t2+60s                      | -            | Yes          |



|              |  |          |
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| <b>5.8.3</b> | <b>For PGUs Type 2 and storage systems</b> | <b>P</b> |
|--------------|--|----------|



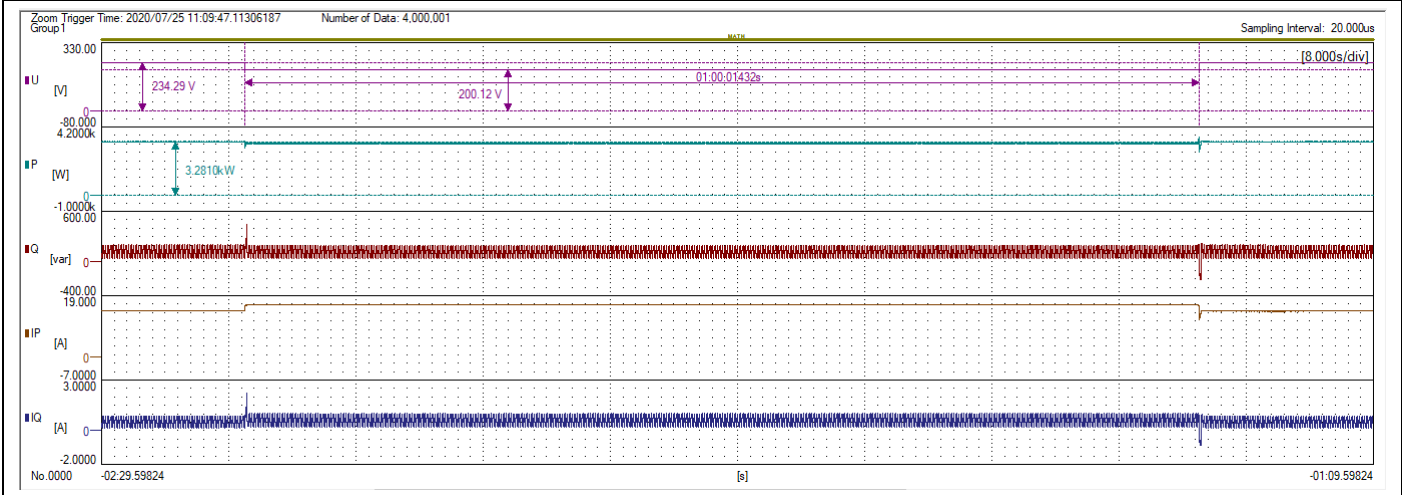
**5.8.3 For PGUs Type 2 and storage systems P**

**4.1**

|                     | No.               | Parameter  | Phase reference       | Reference time                    | Value (unit) | Value        |
|---------------------|-------------------|--|-----------------------|-----------------------------------|--------------|--------------|
| General information | 0                 | Test no.   | -                     | -                                 | -            | 4.1          |
|                     | 1                 | Date   | -                     | -                                 | [dd.mm.yyyy] | 25. 07. 2020 |
|                     | 2                 | Time ( Start of test)  | -                     | -                                 | [hh:mm:ss.f] | 11:09:47:113 |
|                     | 3                 | Type of fault (number of affected phases)                            | -                     | -                                 | -            | N/A          |
|                     | 4                 | Drop depth setpoint  | Phase                 | -                                 | [p.u.]       | 0.85         |
|                     | 5                 | Drop duration setpoint   | Total                 | -                                 | [ms]         | 60000        |
|                     | 6                 | Fault occurrence (t1)  | Total                 | -                                 | [ms]         | 140263       |
|                     | 7                 | Fault clearance (t2)   | Total                 | -                                 | [ms]         | 140549       |
|                     | 8                 | Fault duration determined from test                                  | Total                 | -                                 | [ms]         | 60014        |
|                     | 9                 | Measured value of voltage drop / increase                            | Total                 | t1+100 ms to t2 and t1-10 s to t1 | [p.u.]       | 0.13         |
| 10                  | Positive sequence |  | N/A                   |                                   |              |              |
| Before t1           | 11                | Voltage  | Phase to Neutral      | t1-10 s to t1                     | [p.u.]       | 1.00         |
|                     | 12                | Current  | Positive sequence     | t1-500 ms to t1-100 ms            | [p.u.]       | N/A          |
|                     | 13                | Active power   | Total                 | t1-10 s to t1                     | [p.u.]       | 1.00         |
|                     | 14                |  | Positive sequence     | t1-10 s to t1                     | [p.u.]       | N/A          |
|                     | 15                | Reactive power   | Positive sequence     | t1-10 s to t1                     | [p.u.]       | N/A          |
|                     | 16                |  | Total                 | t1-10 s to t1                     | [p.u.]       | 0.03         |
|                     | 17                | cos φ  | -                     | t1-10 s to t1                     | [p.u.]       | 1.00         |
| t1 till t2          | 18                | Voltage  | Phase to Neutral      | t1+100 ms to t2-20 ms             | [p.u.]       | 0.15         |
|                     | 19                | Phase current  | Phase 1               | t1+60 ms                          | [p.u.]       | 1.13         |
|                     | 20                |  | Phase 2               | t1+60 ms                          | [p.u.]       | N/A*         |
|                     | 21                |  | Phase 3               | t1+60 ms                          | [p.u.]       | N/A*         |
|                     | 22                | Phase current  | Phase 1               | t1 +100 ms                        | [p.u.]       | 1.12         |
|                     | 23                |  | Phase 2               | t1 +100 ms                        | [p.u.]       | N/A          |
|                     | 24                |  | Phase 3               | t1 +100 ms                        | [p.u.]       | N/A          |
|                     | 25                | Active power   | Total                 | t1+100 ms to t2-20 ms             | [p.u.]       | 0.96         |
| 26                  | Positive sequence |  | t1+100 ms to t2-20 ms | [p.u.]                            | N/A          |              |
| After t2            | 27                | Voltage  | Phase to Neutral      | t2+3 s to t2+10 s                 | [p.u.]       | 1            |
|                     | 28                | Active power   | Positive sequence     | t2+3 s to t2+10 s                 | [p.u.]       | N/A          |
|                     | 29                |  | Total                 | t2+3 s to t2+10 s                 | [p.u.]       | 0.66         |
|                     | 30                | Response time active power   | Positive sequence     | -                                 | [s]          | N/A          |
|                     | 31                | Reactive power   | Positive sequence     | t2+3 s to t2+10 s                 | [p.u.]       | N/A          |
|                     | 32                |  | Total                 | t2+3 s to t2+10 s                 | [p.u.]       | 0.03         |
|                     | 33                | Response time reactive power   | Positive sequence     | -                                 | [s]          | N/A          |
|                     | 34                | EZE didn't disconnect from grid within 60s after fault ended yes/no? | -                     | t2 to t2+60s                      | -            | Yes          |



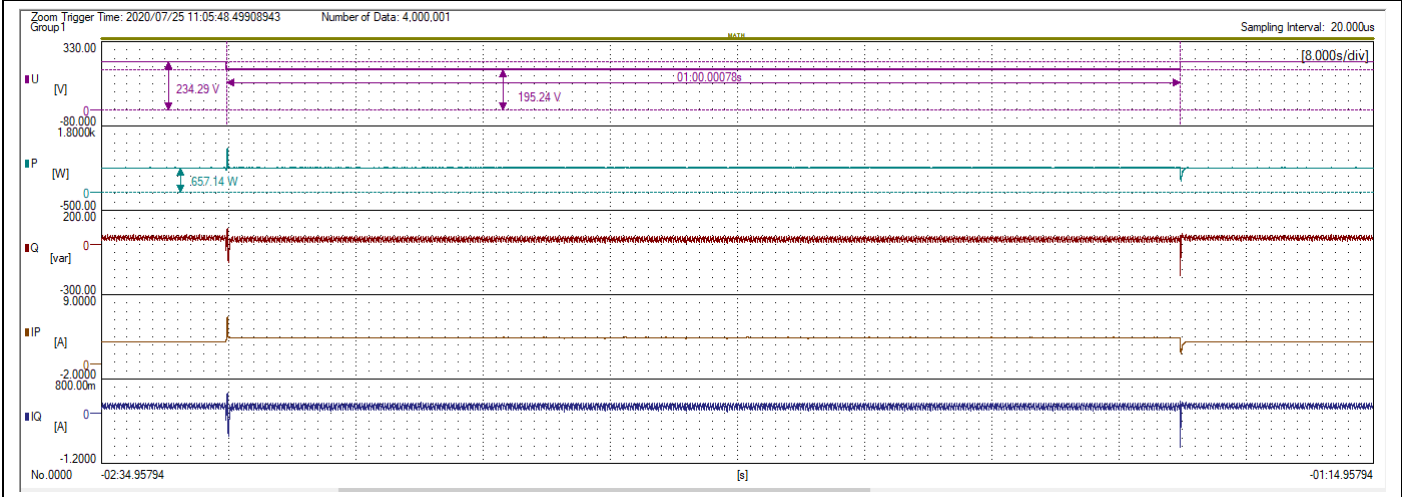
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| <b>5.8.3</b> | <b>For PGUs Type 2 and storage systems</b> | <b>P</b> |
|--------------|--|----------|



| 5.8.3               |                   | For PGUs Type 2 and storage systems                                  |                       |                                   |              | P            |
|---------------------|-------------------|--|-----------------------|-----------------------------------|--------------|--------------|
| 4.2                 |                   |  |                       |                                   |              |              |
|                     | No.               | Parameter  | Phase reference       | Reference time                    | Value (unit) | Value        |
| General information | 0                 | Test no.   | -                     | -                                 | -            | 4.2          |
|                     | 1                 | Date   | -                     | -                                 | [dd.mm.yyyy] | 25. 07. 2020 |
|                     | 2                 | Time ( Start of test)  | -                     | -                                 | [hh:mm:ss.f] | 11:05:48:499 |
|                     | 3                 | Type of fault (number of affected phases)                            | -                     | -                                 | -            | N/A          |
|                     | 4                 | Drop depth setpoint  | Phase                 | -                                 | [p.u.]       | 0.85         |
|                     | 5                 | Drop duration setpoint   | Total                 | -                                 | [ms]         | 60000        |
|                     | 6                 | Fault occurrence (t1)  | Total                 | -                                 | [ms]         | 147126       |
|                     | 7                 | Fault clearance (t2)   | Total                 | -                                 | [ms]         | 147125       |
|                     | 8                 | Fault duration determined from test                                  | Total                 | -                                 | [ms]         | 60001        |
|                     | 9                 | Measured value of voltage drop / increase                            | Total                 | t1+100 ms to t2 and t1-10 s to t1 | [p.u.]       | 0.12         |
| 10                  | Positive sequence |  | N/A                   |                                   |              |              |
| Before t1           | 11                | Voltage  | Phase to Neutral      | t1-10 s to t1                     | [p.u.]       | 1.00         |
|                     | 12                | Current  | Positive sequence     | t1-500 ms to t1-100 ms            | [p.u.]       | N/A          |
|                     | 13                | Active power   | Total                 | t1-10 s to t1                     | [p.u.]       | 0.20         |
|                     | 14                |  | Positive sequence     | t1-10 s to t1                     | [p.u.]       | N/A          |
|                     | 15                | Reactive power   | Positive sequence     | t1-10 s to t1                     | [p.u.]       | N/A          |
|                     | 16                |  | Total                 | t1-10 s to t1                     | [p.u.]       | 0.01         |
|                     | 17                | cos φ  | -                     | t1-10 s to t1                     | [p.u.]       | 1.00         |
| t1 till t2          | 18                | Voltage  | Phase to Neutral      | t1+100 ms to t2-20 ms             | [p.u.]       | 0.15         |
|                     | 19                | Phase current  | Phase 1               | t1+60 ms                          | [p.u.]       | 26.62        |
|                     | 20                |  | Phase 2               | t1+60 ms                          | [p.u.]       | N/A*         |
|                     | 21                |  | Phase 3               | t1+60 ms                          | [p.u.]       | N/A*         |
|                     | 22                | Phase current  | Phase 1               | t1 +100 ms                        | [p.u.]       | 39.97        |
|                     | 23                |  | Phase 2               | t1 +100 ms                        | [p.u.]       | N/A          |
|                     | 24                |  | Phase 3               | t1 +100 ms                        | [p.u.]       | N/A          |
|                     | 25                | Active power   | Total                 | t1+100 ms to t2-20 ms             | [p.u.]       | 0.20         |
| 26                  | Positive sequence |  | t1+100 ms to t2-20 ms | [p.u.]                            | N/A          |              |
| After t2            | 27                | Voltage  | Phase to Neutral      | t2+3 s to t2+10 s                 | [p.u.]       | 1            |
|                     | 28                | Active power   | Positive sequence     | t2+3 s to t2+10 s                 | [p.u.]       | N/A          |
|                     | 29                |  | Total                 | t2+3 s to t2+10 s                 | [p.u.]       | 0.20         |
|                     | 30                | Response time active power   | Positive sequence     | -                                 | [s]          | N/A          |
|                     | 31                | Reactive power   | Positive sequence     | t2+3 s to t2+10 s                 | [p.u.]       | N/A          |
|                     | 32                |  | Total                 | t2+3 s to t2+10 s                 | [p.u.]       | 0.01         |
|                     | 33                | Response time reactive power   | Positive sequence     | -                                 | [s]          | N/A          |
|                     | 34                | EZE didn't disconnect from grid within 60s after fault ended yes/no? | -                     | t2 to t2+60s                      | -            | Yes          |



5.8.3 For PGUs Type 2 and storage systems P

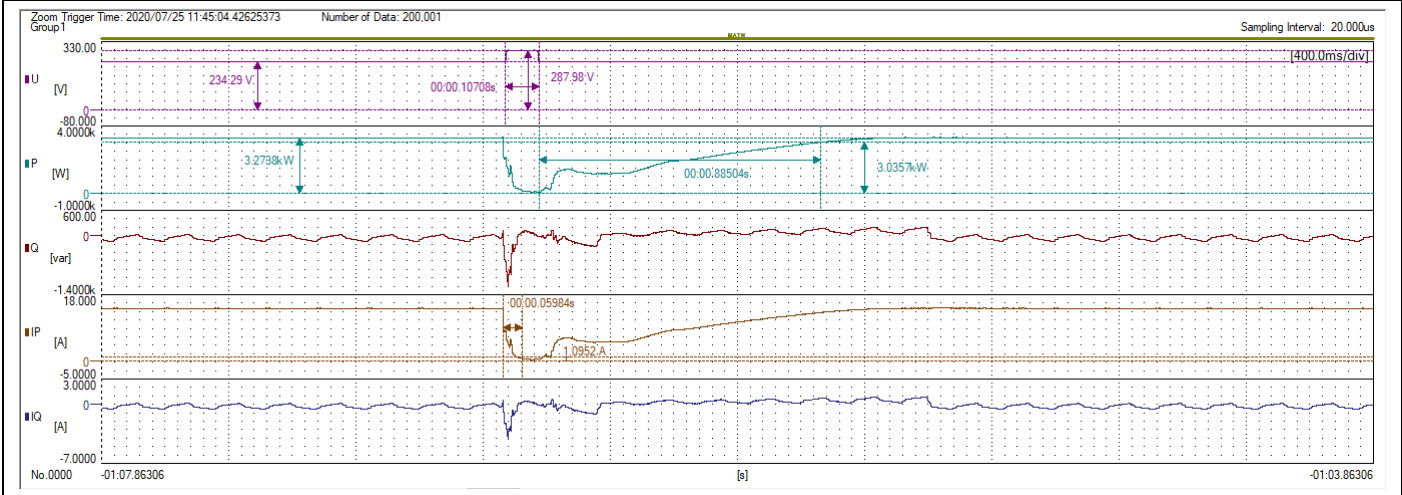




| 5.8.3               |                   | For PGUs Type 2 and storage systems                                  |                       |                                   |              | P            |
|---------------------|-------------------|--|-----------------------|-----------------------------------|--------------|--------------|
| 5.1                 |                   |  |                       |                                   |              |              |
|                     | No.               | Parameter  | Phase reference       | Reference time                    | Value (unit) | Value        |
| General information | 0                 | Test no.   | -                     | -                                 | -            | 5.1          |
|                     | 1                 | Date   | -                     | -                                 | [dd.mm.yyyy] | 25. 07. 2020 |
|                     | 2                 | Time ( Start of test)  | -                     | -                                 | [hh:mm:ss.f] | 11:45:04:426 |
|                     | 3                 | Type of fault (number of affected phases)                            | -                     | -                                 | -            | N/A          |
|                     | 4                 | Drop depth setpoint  | Phase                 | -                                 | [p.u.]       | 1.2          |
|                     | 5                 | Drop duration setpoint   | Total                 | -                                 | [ms]         | 100          |
|                     | 6                 | Fault occurrence (t1)  | Total                 | -                                 | [ms]         | 66593.04     |
|                     | 7                 | Fault clearance (t2)   | Total                 | -                                 | [ms]         | 66485.96     |
|                     | 8                 | Fault duration determined from test                                  | Total                 | -                                 | [ms]         | 107          |
|                     | 9                 | Measured value of voltage drop / increase                            | Total                 | t1+100 ms to t2 and t1-10 s to t1 | [p.u.]       | -0.22        |
| 10                  | Positive sequence |  | N/A                   |                                   |              |              |
| Before t1           | 11                | Voltage  | Phase to Neutral      | t1-10 s to t1                     | [p.u.]       | 1.00         |
|                     | 12                | Current  | Positive sequence     | t1-500 ms to t1-100 ms            | [p.u.]       | N/A          |
|                     | 13                | Active power   | Total                 | t1-10 s to t1                     | [p.u.]       | 1.00         |
|                     | 14                |  | Positive sequence     | t1-10 s to t1                     | [p.u.]       | N/A          |
|                     | 15                | Reactive power   | Positive sequence     | t1-10 s to t1                     | [p.u.]       | N/A          |
|                     | 16                |  | Total                 | t1-10 s to t1                     | [p.u.]       | 0.02         |
|                     | 17                | cos φ  | -                     | t1-10 s to t1                     | [p.u.]       | 1.00         |
| t1 till t2          | 18                | Voltage  | Phase to Neutral      | t1+100 ms to t2-20 ms             | [p.u.]       | 0.15         |
|                     | 19                | Phase current  | Phase 1               | t1+60 ms                          | [p.u.]       | 0.04         |
|                     | 20                |  | Phase 2               | t1+60 ms                          | [p.u.]       | N/A*         |
|                     | 21                |  | Phase 3               | t1+60 ms                          | [p.u.]       | N/A*         |
|                     | 22                | Phase current  | Phase 1               | t1 +100 ms                        | [p.u.]       | 0.03         |
|                     | 23                |  | Phase 2               | t1 +100 ms                        | [p.u.]       | N/A          |
|                     | 24                |  | Phase 3               | t1 +100 ms                        | [p.u.]       | N/A          |
|                     | 25                | Active power   | Total                 | t1+100 ms to t2-20 ms             | [p.u.]       | 0.02         |
| 26                  | Positive sequence |  | t1+100 ms to t2-20 ms | [p.u.]                            | N/A          |              |
| After t2            | 27                | Voltage  | Phase to Neutral      | t2+3 s to t2+10 s                 | [p.u.]       | 1            |
|                     | 28                | Active power   | Positive sequence     | t2+3 s to t2+10 s                 | [p.u.]       | N/A          |
|                     | 29                |  | Total                 | t2+3 s to t2+10 s                 | [p.u.]       | 1.00         |
|                     | 30                | Response time active power   | Positive sequence     | -                                 | [s]          | N/A          |
|                     | 31                | Reactive power   | Positive sequence     | t2+3 s to t2+10 s                 | [p.u.]       | N/A          |
|                     | 32                |  | Total                 | t2+3 s to t2+10 s                 | [p.u.]       | 0.02         |
|                     | 33                | Response time reactive power   | Positive sequence     | -                                 | [s]          | N/A          |
|                     | 34                | EZE didn't disconnect from grid within 60s after fault ended yes/no? | -                     | t2 to t2+60s                      | -            | Yes          |



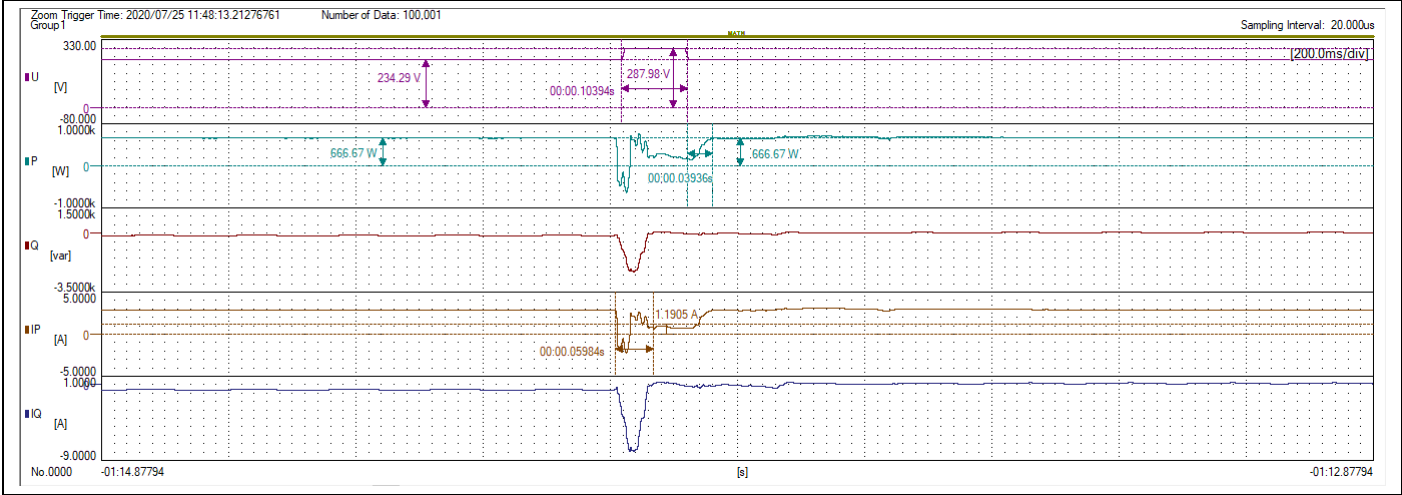
5.8.3 For PGUs Type 2 and storage systems P



| 5.8.3               |                   | For PGUs Type 2 and storage systems                                  |                       |                                   |              | P            |
|---------------------|-------------------|--|-----------------------|-----------------------------------|--------------|--------------|
| 5.2                 |                   |  |                       |                                   |              |              |
|                     | No.               | Parameter  | Phase reference       | Reference time                    | Value (unit) | Value        |
| General information | 0                 | Test no.   | -                     | -                                 | -            | 5.1          |
|                     | 1                 | Date   | -                     | -                                 | [dd.mm.yyyy] | 25. 07. 2020 |
|                     | 2                 | Time ( Start of test)  | -                     | -                                 | [hh:mm:ss.f] | 11:48:13:213 |
|                     | 3                 | Type of fault (number of affected phases)                            | -                     | -                                 | -            | N/A          |
|                     | 4                 | Drop depth setpoint  | Phase                 | -                                 | [p.u.]       | 1.2          |
|                     | 5                 | Drop duration setpoint   | Total                 | -                                 | [ms]         | 100          |
|                     | 6                 | Fault occurrence (t1)  | Total                 | -                                 | [ms]         | 74062        |
|                     | 7                 | Fault clearance (t2)   | Total                 | -                                 | [ms]         | 73955        |
|                     | 8                 | Fault duration determined from test                                  | Total                 | -                                 | [ms]         | 107          |
|                     | 9                 | Measured value of voltage drop / increase                            | Total                 | t1+100 ms to t2 and t1-10 s to t1 | [p.u.]       | -0.09        |
| 10                  | Positive sequence |  | N/A                   |                                   |              |              |
| Before t1           | 11                | Voltage  | Phase to Neutral      | t1-10 s to t1                     | [p.u.]       | 1.00         |
|                     | 12                | Current  | Positive sequence     | t1-500 ms to t1-100 ms            | [p.u.]       | N/A          |
|                     | 13                | Active power   | Total                 | t1-10 s to t1                     | [p.u.]       | 0.20         |
|                     | 14                |  | Positive sequence     | t1-10 s to t1                     | [p.u.]       | N/A          |
|                     | 15                | Reactive power   | Positive sequence     | t1-10 s to t1                     | [p.u.]       | N/A          |
|                     | 16                |  | Total                 | t1-10 s to t1                     | [p.u.]       | 0.03         |
|                     | 17                | cos φ  | -                     | t1-10 s to t1                     | [p.u.]       | 1            |
| t1 till t2          | 18                | Voltage  | Phase to Neutral      | t1+100 ms to t2-20 ms             | [p.u.]       | 0.15         |
|                     | 19                | Phase current  | Phase 1               | t1+60 ms                          | [p.u.]       | 0.07         |
|                     | 20                |  | Phase 2               | t1+60 ms                          | [p.u.]       | N/A*         |
|                     | 21                |  | Phase 3               | t1+60 ms                          | [p.u.]       | N/A*         |
|                     | 22                | Phase current  | Phase 1               | t1 +100 ms                        | [p.u.]       | 0.05         |
|                     | 23                |  | Phase 2               | t1 +100 ms                        | [p.u.]       | N/A          |
|                     | 24                |  | Phase 3               | t1 +100 ms                        | [p.u.]       | N/A          |
|                     | 25                | Active power   | Total                 | t1+100 ms to t2-20 ms             | [p.u.]       | 0.04         |
| 26                  | Positive sequence |  | t1+100 ms to t2-20 ms | [p.u.]                            | N/A          |              |
| After t2            | 27                | Voltage  | Phase to Neutral      | t2+3 s to t2+10 s                 | [p.u.]       | 1            |
|                     | 28                | Active power   | Positive sequence     | t2+3 s to t2+10 s                 | [p.u.]       | N/A          |
|                     | 29                |  | Total                 | t2+3 s to t2+10 s                 | [p.u.]       | 0.20         |
|                     | 30                | Response time active power   | Positive sequence     | -                                 | [s]          | N/A          |
|                     | 31                | Reactive power   | Positive sequence     | t2+3 s to t2+10 s                 | [p.u.]       | N/A          |
|                     | 32                |  | Total                 | t2+3 s to t2+10 s                 | [p.u.]       | 0.04         |
|                     | 33                | Response time reactive power   | Positive sequence     | -                                 | [s]          | N/A          |
|                     | 34                | EZE didn't disconnect from grid within 60s after fault ended yes/no? | -                     | t2 to t2+60s                      | -            | Yes          |



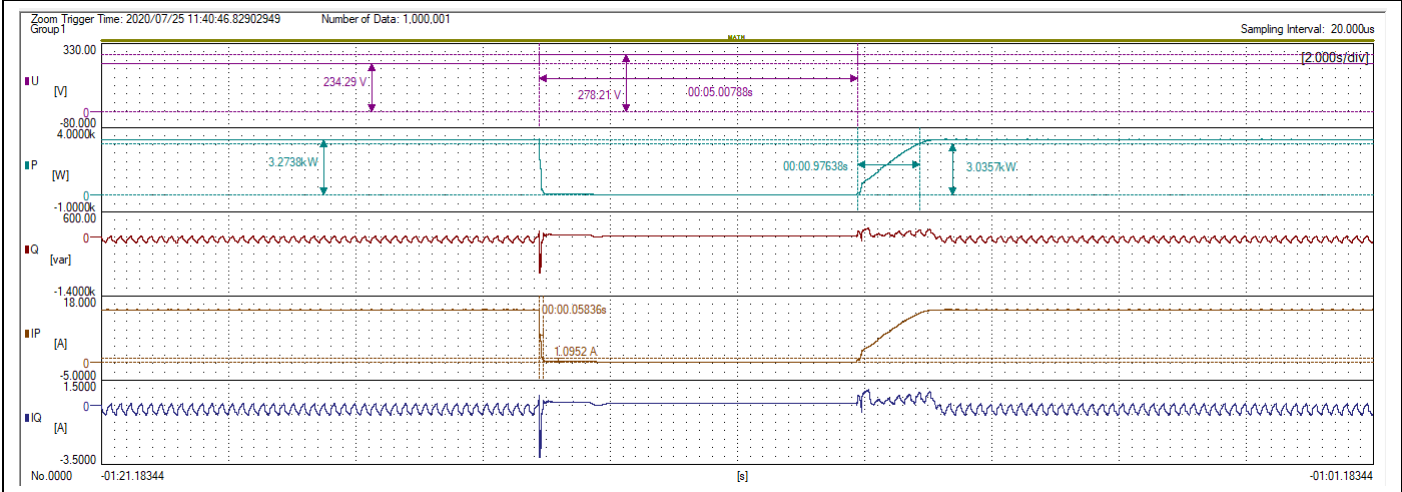
|              |  |          |
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| <b>5.8.3</b> | <b>For PGUs Type 2 and storage systems</b> | <b>P</b> |
|--------------|--|----------|



| 5.8.3               |                   | For PGUs Type 2 and storage systems                                  |                       |                                   |              | P            |
|---------------------|-------------------|--|-----------------------|-----------------------------------|--------------|--------------|
| 6.1                 |                   |  |                       |                                   |              |              |
|                     | No.               | Parameter  | Phase reference       | Reference time                    | Value (unit) | Value        |
| General information | 0                 | Test no.   | -                     | -                                 | -            | 6.1          |
|                     | 1                 | Date   | -                     | -                                 | [dd.mm.yyyy] | 25. 07. 2020 |
|                     | 2                 | Time ( Start of test)  | -                     | -                                 | [hh:mm:ss.f] | 11:40:46:829 |
|                     | 3                 | Type of fault (number of affected phases)                            | -                     | -                                 | -            | N/A          |
|                     | 4                 | Drop depth setpoint  | Phase                 | -                                 | [p.u.]       | 1.2          |
|                     | 5                 | Drop duration setpoint   | Total                 | -                                 | [ms]         | 5000         |
|                     | 6                 | Fault occurrence (t1)  | Total                 | -                                 | [ms]         | 74294        |
|                     | 7                 | Fault clearance (t2)   | Total                 | -                                 | [ms]         | 79286        |
|                     | 8                 | Fault duration determined from test                                  | Total                 | -                                 | [ms]         | 5008         |
|                     | 9                 | Measured value of voltage drop / increase                            | Total                 | t1+100 ms to t2 and t1-10 s to t1 | [p.u.]       | -0.20        |
| 10                  | Positive sequence |  | N/A                   |                                   |              |              |
| Before t1           | 11                | Voltage  | Phase to Neutral      | t1-10 s to t1                     | [p.u.]       | 1.00         |
|                     | 12                | Current  | Positive sequence     | t1-500 ms to t1-100 ms            | [p.u.]       | N/A          |
|                     | 13                | Active power   | Total                 | t1-10 s to t1                     | [p.u.]       | 1.00         |
|                     | 14                |  | Positive sequence     | t1-10 s to t1                     | [p.u.]       | N/A          |
|                     | 15                | Reactive power   | Positive sequence     | t1-10 s to t1                     | [p.u.]       | N/A          |
|                     | 16                |  | Total                 | t1-10 s to t1                     | [p.u.]       | 0.02         |
|                     | 17                | cos φ  | -                     | t1-10 s to t1                     | [p.u.]       | 1            |
| t1 till t2          | 18                | Voltage  | Phase to Neutral      | t1+100 ms to t2-20 ms             | [p.u.]       | 0.15         |
|                     | 19                | Phase current  | Phase 1               | t1+60 ms                          | [p.u.]       | 0.04         |
|                     | 20                |  | Phase 2               | t1+60 ms                          | [p.u.]       | N/A*         |
|                     | 21                |  | Phase 3               | t1+60 ms                          | [p.u.]       | N/A*         |
|                     | 22                | Phase current  | Phase 1               | t1 +100 ms                        | [p.u.]       | 0.02         |
|                     | 23                |  | Phase 2               | t1 +100 ms                        | [p.u.]       | N/A          |
|                     | 24                |  | Phase 3               | t1 +100 ms                        | [p.u.]       | N/A          |
|                     | 25                | Active power   | Total                 | t1+100 ms to t2-20 ms             | [p.u.]       | 0.01         |
| 26                  | Positive sequence |  | t1+100 ms to t2-20 ms | [p.u.]                            | N/A          |              |
| After t2            | 27                | Voltage  | Phase to Neutral      | t2+3 s to t2+10 s                 | [p.u.]       | 1            |
|                     | 28                | Active power   | Positive sequence     | t2+3 s to t2+10 s                 | [p.u.]       | N/A          |
|                     | 29                |  | Total                 | t2+3 s to t2+10 s                 | [p.u.]       | 1.00         |
|                     | 30                | Response time active power   | Positive sequence     | -                                 | [s]          | N/A          |
|                     | 31                | Reactive power   | Positive sequence     | t2+3 s to t2+10 s                 | [p.u.]       | N/A          |
|                     | 32                |  | Total                 | t2+3 s to t2+10 s                 | [p.u.]       | 0.02         |
|                     | 33                | Response time reactive power   | Positive sequence     | -                                 | [s]          | N/A          |
|                     | 34                | EZE didn't disconnect from grid within 60s after fault ended yes/no? | -                     | t2 to t2+60s                      | -            | Yes          |



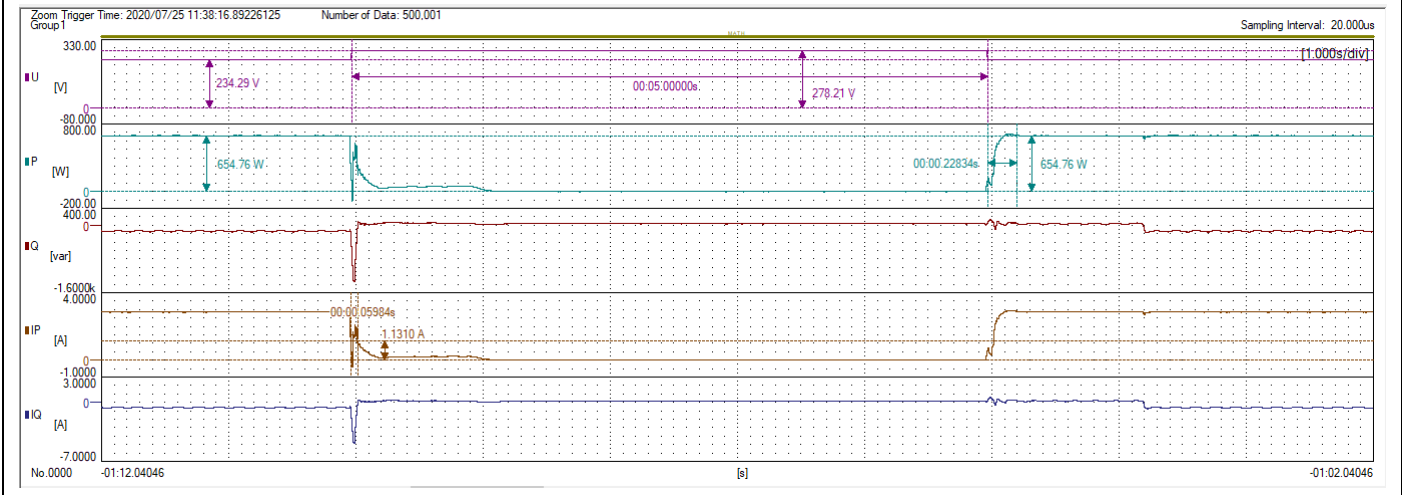
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| <b>5.8.3</b> | <b>For PGUs Type 2 and storage systems</b> | <b>P</b> |
|--------------|--|----------|



| 5.8.3               |                   | For PGUs Type 2 and storage systems                                  |                       |                                   |              | P            |
|---------------------|-------------------|--|-----------------------|-----------------------------------|--------------|--------------|
| 6.2                 |                   |  |                       |                                   |              |              |
|                     | No.               | Parameter  | Phase reference       | Reference time                    | Value (unit) | Value        |
| General information | 0                 | Test no.   | -                     | -                                 | -            | 6.2          |
|                     | 1                 | Date   | -                     | -                                 | [dd.mm.yyyy] | 25. 07. 2020 |
|                     | 2                 | Time ( Start of test)  | -                     | -                                 | [hh:mm:ss.f] | 11:38:16:892 |
|                     | 3                 | Type of fault (number of affected phases)                            | -                     | -                                 | -            | N/A          |
|                     | 4                 | Drop depth setpoint  | Phase                 | -                                 | [p.u.]       | 1.2          |
|                     | 5                 | Drop duration setpoint   | Total                 | -                                 | [ms]         | 5000         |
|                     | 6                 | Fault occurrence (t1)  | Total                 | -                                 | [ms]         | 70070        |
|                     | 7                 | Fault clearance (t2)   | Total                 | -                                 | [ms]         | 65070        |
|                     | 8                 | Fault duration determined from test                                  | Total                 | -                                 | [ms]         | 5000         |
|                     | 9                 | Measured value of voltage drop / increase                            | Total                 | t1+100 ms to t2 and t1-10 s to t1 | [p.u.]       | -0.20        |
| 10                  | Positive sequence |  | N/A                   |                                   |              |              |
| Before t1           | 11                | Voltage  | Phase to Neutral      | t1-10 s to t1                     | [p.u.]       | 1.00         |
|                     | 12                | Current  | Positive sequence     | t1-500 ms to t1-100 ms            | [p.u.]       | N/A          |
|                     | 13                | Active power   | Total                 | t1-10 s to t1                     | [p.u.]       | 0.20         |
|                     | 14                |  | Positive sequence     | t1-10 s to t1                     | [p.u.]       | N/A          |
|                     | 15                | Reactive power   | Positive sequence     | t1-10 s to t1                     | [p.u.]       | N/A          |
|                     | 16                |  | Total                 | t1-10 s to t1                     | [p.u.]       | 0.04         |
|                     | 17                | cos φ  | -                     | t1-10 s to t1                     | [p.u.]       | 0.98         |
| t1 till t2          | 18                | Voltage  | Phase to Neutral      | t1+100 ms to t2-20 ms             | [p.u.]       | 0.15         |
|                     | 19                | Phase current  | Phase 1               | t1+60 ms                          | [p.u.]       | 0.07         |
|                     | 20                |  | Phase 2               | t1+60 ms                          | [p.u.]       | N/A*         |
|                     | 21                |  | Phase 3               | t1+60 ms                          | [p.u.]       | N/A*         |
|                     | 22                | Phase current  | Phase 1               | t1 +100 ms                        | [p.u.]       | 0.04         |
|                     | 23                |  | Phase 2               | t1 +100 ms                        | [p.u.]       | N/A          |
|                     | 24                |  | Phase 3               | t1 +100 ms                        | [p.u.]       | N/A          |
|                     | 25                | Active power   | Total                 | t1+100 ms to t2-20 ms             | [p.u.]       | 0.01         |
| 26                  | Positive sequence |  | t1+100 ms to t2-20 ms | [p.u.]                            | N/A          |              |
| After t2            | 27                | Voltage  | Phase to Neutral      | t2+3 s to t2+10 s                 | [p.u.]       | 1            |
|                     | 28                | Active power   | Positive sequence     | t2+3 s to t2+10 s                 | [p.u.]       | N/A          |
|                     | 29                |  | Total                 | t2+3 s to t2+10 s                 | [p.u.]       | 0.20         |
|                     | 30                | Response time active power   | Positive sequence     | -                                 | [s]          | N/A          |
|                     | 31                | Reactive power   | Positive sequence     | t2+3 s to t2+10 s                 | [p.u.]       | N/A          |
|                     | 32                |  | Total                 | t2+3 s to t2+10 s                 | [p.u.]       | 0.04         |
|                     | 33                | Response time reactive power   | Positive sequence     | -                                 | [s]          | N/A          |
|                     | 34                | EZE didn't disconnect from grid within 60s after fault ended yes/no? | -                     | t2 to t2+60s                      | -            | Yes          |



|              |  |          |
|--------------|--|----------|
| <b>5.8.3</b> | <b>For PGUs Type 2 and storage systems</b> | <b>P</b> |
|--------------|--|----------|

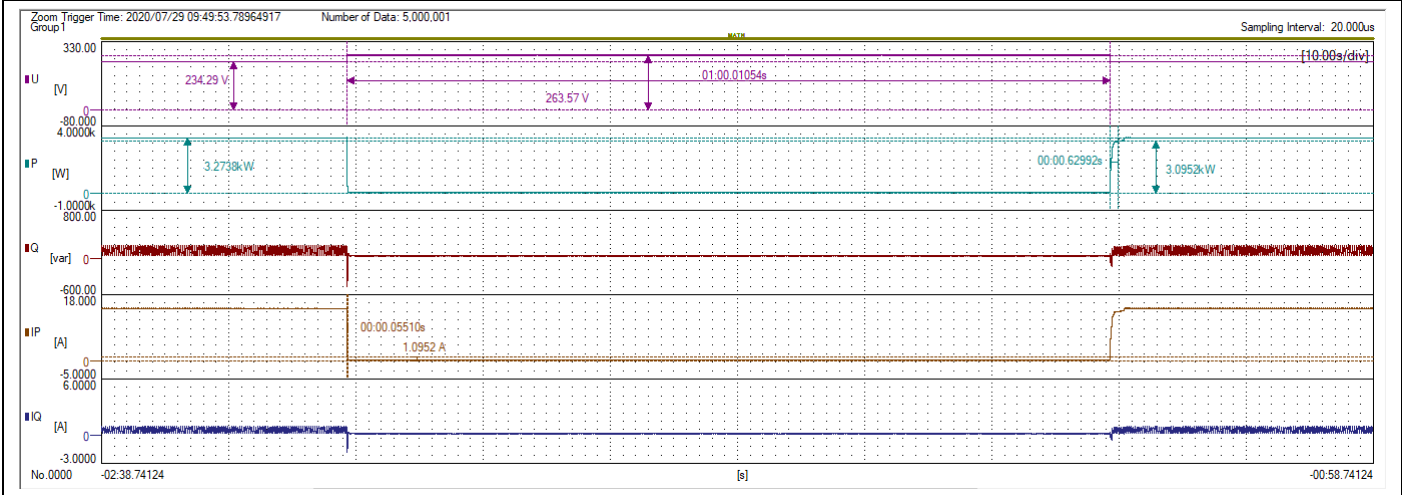




| 5.8.3               |                   | For PGUs Type 2 and storage systems                                  |                       |                                   |              | P            |
|---------------------|-------------------|--|-----------------------|-----------------------------------|--------------|--------------|
| 7.1                 |                   |  |                       |                                   |              |              |
|                     | No.               | Parameter  | Phase reference       | Reference time                    | Value (unit) | Value        |
| General information | 0                 | Test no.   | -                     | -                                 | -            | 7.1          |
|                     | 1                 | Date   | -                     | -                                 | [dd.mm.yyyy] | 29. 07. 2020 |
|                     | 2                 | Time ( Start of test)  | -                     | -                                 | [hh:mm:ss.f] | 09:49:53:790 |
|                     | 3                 | Type of fault (number of affected phases)                            | -                     | -                                 | -            | N/A          |
|                     | 4                 | Drop depth setpoint  | Phase                 | -                                 | [p.u.]       | 1.15         |
|                     | 5                 | Drop duration setpoint   | Total                 | -                                 | [ms]         | 60000        |
|                     | 6                 | Fault occurrence (t1)  | Total                 | -                                 | [ms]         | 139420       |
|                     | 7                 | Fault clearance (t2)   | Total                 | -                                 | [ms]         | 79410        |
|                     | 8                 | Fault duration determined from test                                  | Total                 | -                                 | [ms]         | 60011        |
|                     | 9                 | Measured value of voltage drop / increase                            | Total                 | t1+100 ms to t2 and t1-10 s to t1 | [p.u.]       | -0.13        |
| 10                  | Positive sequence |  | N/A                   |                                   |              |              |
| Before t1           | 11                | Voltage  | Phase to Neutral      | t1-10 s to t1                     | [p.u.]       | 1.00         |
|                     | 12                | Current  | Positive sequence     | t1-500 ms to t1-100 ms            | [p.u.]       | N/A          |
|                     | 13                | Active power   | Total                 | t1-10 s to t1                     | [p.u.]       | 1.00         |
|                     | 14                |  | Positive sequence     | t1-10 s to t1                     | [p.u.]       | N/A          |
|                     | 15                | Reactive power   | Positive sequence     | t1-10 s to t1                     | [p.u.]       | N/A          |
|                     | 16                |  | Total                 | t1-10 s to t1                     | [p.u.]       | 0.04         |
|                     | 17                | cos φ  | -                     | t1-10 s to t1                     | [p.u.]       | 1.00         |
| t1 till t2          | 18                | Voltage  | Phase to Neutral      | t1+100 ms to t2-20 ms             | [p.u.]       | 0.15         |
|                     | 19                | Phase current  | Phase 1               | t1+60 ms                          | [p.u.]       | 0.03         |
|                     | 20                |  | Phase 2               | t1+60 ms                          | [p.u.]       | N/A*         |
|                     | 21                |  | Phase 3               | t1+60 ms                          | [p.u.]       | N/A*         |
|                     | 22                | Phase current  | Phase 1               | t1 +100 ms                        | [p.u.]       | 0.03         |
|                     | 23                |  | Phase 2               | t1 +100 ms                        | [p.u.]       | N/A          |
|                     | 24                |  | Phase 3               | t1 +100 ms                        | [p.u.]       | N/A          |
|                     | 25                | Active power   | Total                 | t1+100 ms to t2-20 ms             | [p.u.]       | 0.02         |
| 26                  | Positive sequence |  | t1+100 ms to t2-20 ms | [p.u.]                            | N/A          |              |
| After t2            | 27                | Voltage  | Phase to Neutral      | t2+3 s to t2+10 s                 | [p.u.]       | 1            |
|                     | 28                | Active power   | Positive sequence     | t2+3 s to t2+10 s                 | [p.u.]       | N/A          |
|                     | 29                |  | Total                 | t2+3 s to t2+10 s                 | [p.u.]       | 1.00         |
|                     | 30                | Response time active power   | Positive sequence     | -                                 | [s]          | N/A          |
|                     | 31                | Reactive power   | Positive sequence     | t2+3 s to t2+10 s                 | [p.u.]       | N/A          |
|                     | 32                |  | Total                 | t2+3 s to t2+10 s                 | [p.u.]       | 0.04         |
|                     | 33                | Response time reactive power   | Positive sequence     | -                                 | [s]          | N/A          |
|                     | 34                | EZE didn't disconnect from grid within 60s after fault ended yes/no? | -                     | t2 to t2+60s                      | -            | Yes          |



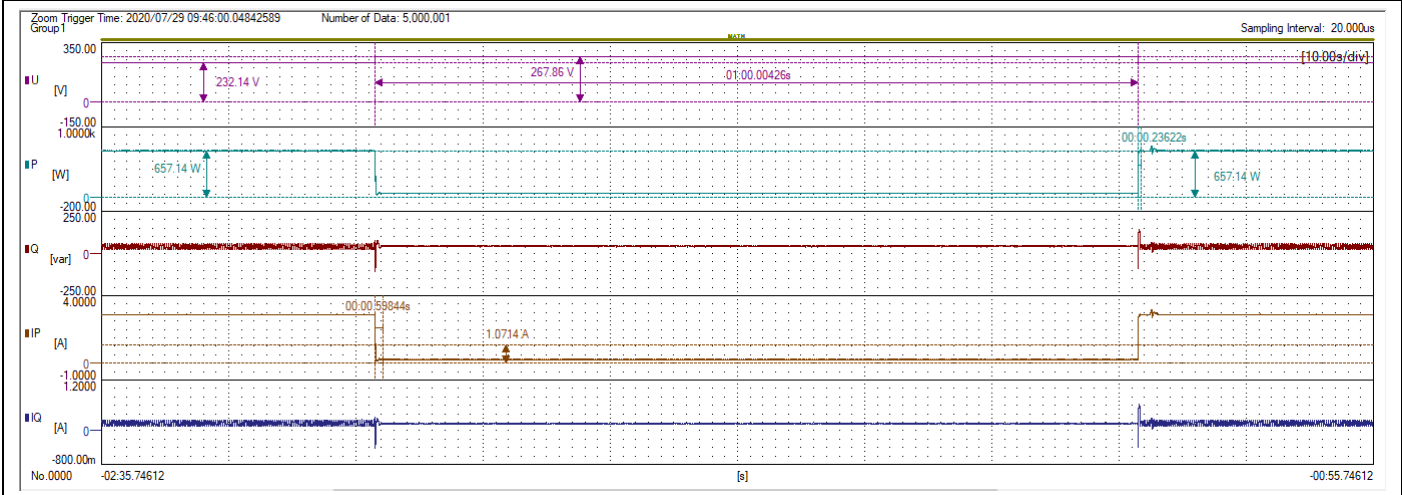
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|--------------|--|----------|
| <b>5.8.3</b> | <b>For PGUs Type 2 and storage systems</b> | <b>P</b> |
|--------------|--|----------|



| 5.8.3               |                   | For PGUs Type 2 and storage systems                                  |                       |                                   |              | P            |
|---------------------|-------------------|--|-----------------------|-----------------------------------|--------------|--------------|
| 7.2                 |                   |  |                       |                                   |              |              |
|                     | No.               | Parameter  | Phase reference       | Reference time                    | Value (unit) | Value        |
| General information | 0                 | Test no.   | -                     | -                                 | -            | 7.2          |
|                     | 1                 | Date   | -                     | -                                 | [dd.mm.yyyy] | 29. 07. 2020 |
|                     | 2                 | Time ( Start of test)  | -                     | -                                 | [hh:mm:ss.f] | 09:46:00:048 |
|                     | 3                 | Type of fault (number of affected phases)                            | -                     | -                                 | -            | N/A          |
|                     | 4                 | Drop depth setpoint  | Phase                 | -                                 | [p.u]        | 1.15         |
|                     | 5                 | Drop duration setpoint   | Total                 | -                                 | [ms]         | 60000        |
|                     | 6                 | Fault occurrence (t1)  | Total                 | -                                 | [ms]         | 134220       |
|                     | 7                 | Fault clearance (t2)   | Total                 | -                                 | [ms]         | 74216        |
|                     | 8                 | Fault duration determined from test                                  | Total                 | -                                 | [ms]         | 60004        |
|                     | 9                 | Measured value of voltage drop / increase                            | Total                 | t1+100 ms to t2 and t1-10 s to t1 | [p.u.]       | -0.15        |
| 10                  | Positive sequence |  | N/A                   |                                   |              |              |
| Before t1           | 11                | Voltage  | Phase to Neutral      | t1-10 s to t1                     | [p.u.]       | 1.00         |
|                     | 12                | Current  | Positive sequence     | t1-500 ms to t1-100 ms            | [p.u.]       | N/A          |
|                     | 13                | Active power   | Total                 | t1-10 s to t1                     | [p.u.]       | 0.13         |
|                     | 14                |  | Positive sequence     | t1-10 s to t1                     | [p.u.]       | N/A          |
|                     | 15                | Reactive power   | Positive sequence     | t1-10 s to t1                     | [p.u.]       | N/A          |
|                     | 16                |  | Total                 | t1-10 s to t1                     | [p.u.]       | 0.01         |
|                     | 17                | cos φ  | -                     | t1-10 s to t1                     | [p.u.]       | 1.00         |
| t1 till t2          | 18                | Voltage  | Phase to Neutral      | t1+100 ms to t2-20 ms             | [p.u.]       | 0.15         |
|                     | 19                | Phase current  | Phase 1               | t1+60 ms                          | [p.u.]       | 0.03         |
|                     | 20                |  | Phase 2               | t1+60 ms                          | [p.u.]       | N/A*         |
|                     | 21                |  | Phase 3               | t1+60 ms                          | [p.u.]       | N/A*         |
|                     | 22                | Phase current  | Phase 1               | t1 +100 ms                        | [p.u.]       | 0.03         |
|                     | 23                |  | Phase 2               | t1 +100 ms                        | [p.u.]       | N/A          |
|                     | 24                |  | Phase 3               | t1 +100 ms                        | [p.u.]       | N/A          |
|                     | 25                | Active power   | Total                 | t1+100 ms to t2-20 ms             | [p.u.]       | 0.02         |
| 26                  | Positive sequence |  | t1+100 ms to t2-20 ms | [p.u.]                            | N/A          |              |
| After t2            | 27                | Voltage  | Phase to Neutral      | t2+3 s to t2+10 s                 | [p.u.]       | 1            |
|                     | 28                | Active power   | Positive sequence     | t2+3 s to t2+10 s                 | [p.u.]       | N/A          |
|                     | 29                |  | Total                 | t2+3 s to t2+10 s                 | [p.u.]       | 0.13         |
|                     | 30                | Response time active power   | Positive sequence     | -                                 | [s]          | N/A          |
|                     | 31                | Reactive power   | Positive sequence     | t2+3 s to t2+10 s                 | [p.u.]       | N/A          |
|                     | 32                |  | Total                 | t2+3 s to t2+10 s                 | [p.u.]       | 0.01         |
|                     | 33                | Response time reactive power   | Positive sequence     | -                                 | [s]          | N/A          |
|                     | 34                | EZE didn't disconnect from grid within 60s after fault ended yes/no? | -                     | t2 to t2+60s                      | -            | Yes          |



**5.8.3** For PGUs Type 2 and storage systems **P**



# Annex No. 1

## Pictures of the unit

**Enclosure front(SOFAR 2700TL-G3、SOFAR 3300TL-G3)**



**Enclosure front(SOFAR 1100TL-G3、SOFAR 1600TL-G3、SOFAR 2200TL-G3)**



### Enclosure(connectors)



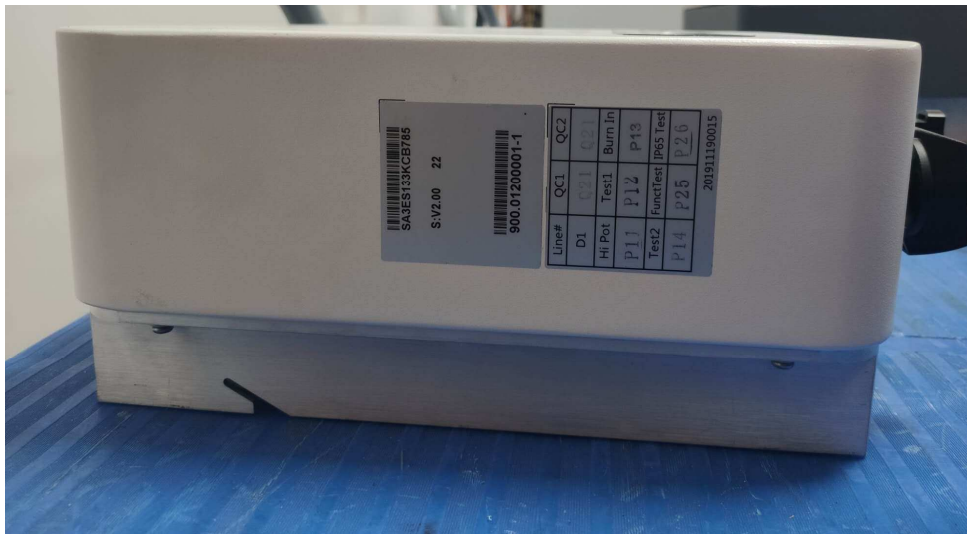
### Enclosure top side(SOFAR 2700TL-G3、SOFAR 3300TL-G3)



### Enclosure top side(SOFAR 1100TL-G3、SOFAR 1600TL-G3、SOFAR 2200TL-G3)



### Enclosure left side



### Enclosure right side

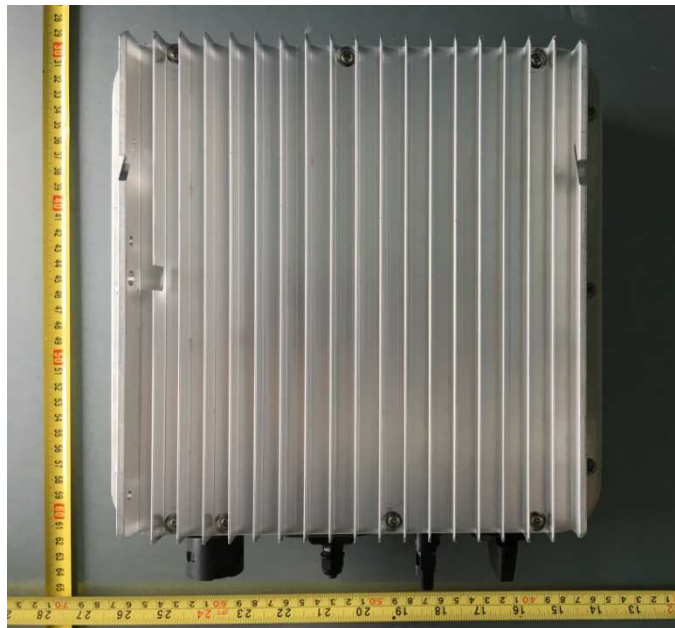




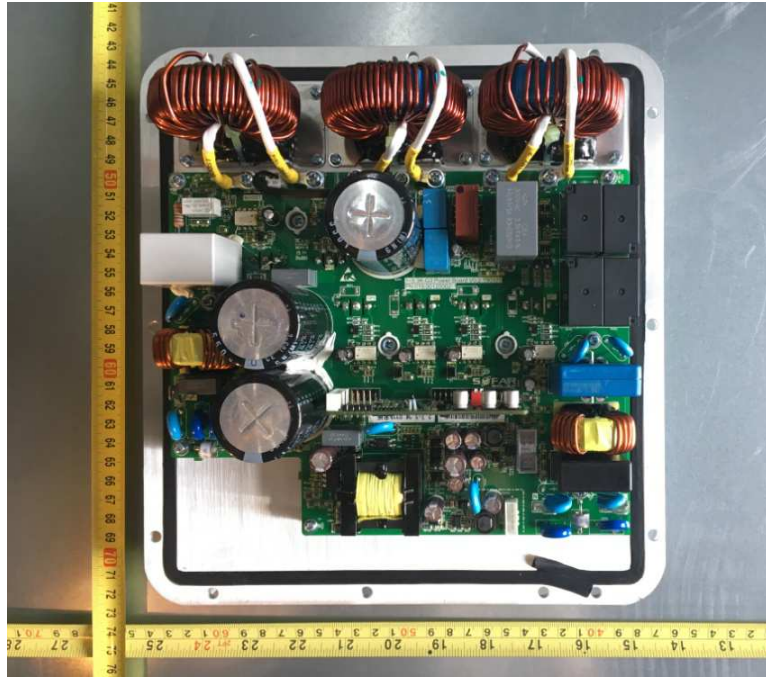
**Enclosure back(SOFAR 2700TL-G3、 SOFAR 3300TL-G3)**



**Enclosure back(SOFAR 1100TL-G3、 SOFAR 1600TL-G3、 SOFAR 2200TL-G3)**



## Enclosure open



# Annex No. 2

## Test Equipment list

**Date(s) of performance test: 2020-03-20 to 2020-08-28**

| Equipment   | Internal No. | Manufacturer | Type         | Serial No.    | Last Calibration               |
|---|--------------|--------------|--------------|---------------|--------------------------------|
| Power Analyser                                    | A4080002DG   | YOKOGAWA     | WT3000       | 91M210852     | Sep. 12, 2019                  |
| AC Source   | A7040019DG   | Chroma       | 61512        | 61512000439   | Monitored by<br>Power Analyzer |
|   | A7040020DG   | Chroma       | 61512        | 61512000438   |                                |
| DC Simulation<br>Power Supply                     | A7040016DG   | Chroma       | 62150H-1000S | 62150EF00490  |                                |
|   | A7040017DG   | Chroma       | 620028       | 620028EF00120 |                                |
| RLC Load  | A7150027DG   | Qunling      | ACLT-3803H   | 93VOO2869     |                                |
| Eight Channel<br>Digital Phosphor<br>Oscilloscope | A4089017DG   | YOKOGAWA     | DL850        | 91N726247     | Sep. 24, 2019                  |
| Oscilloscope probe                                | A1490008DG   | YOKOGAWA     | 701901       | //            | Sep. 20, 2019                  |
|   | A1490009DG   | YOKOGAWA     | 701901       | //            | Sep. 20, 2019                  |
|   | A1490010DG   | YOKOGAWA     | 701901       | //            | Sep. 20, 2019                  |
| Current transducer                                | A1060007DG   | YOKOGAWA     | CT200        | 1130700012    | Sep. 12, 2019                  |
|   | A1060008DG   | YOKOGAWA     | CT200        | 1130700017    | Sep. 12, 2019                  |
|   | A1060009DG   | YOKOGAWA     | CT200        | 1130700019    | Sep. 12, 2019                  |

# End of Test Report